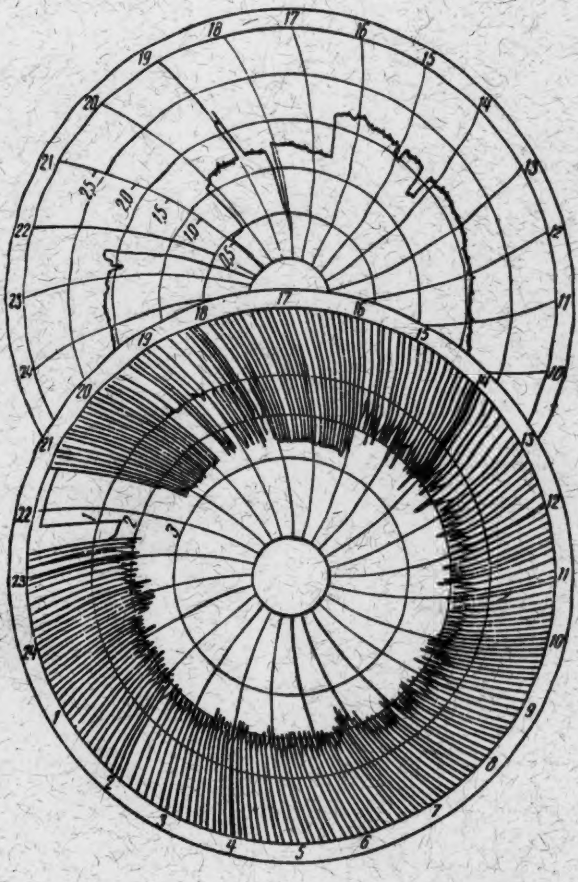
number 4
april 1958

METALLURGIST

translated from Russian



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Foremost steel worker of the electrosmelting division of the Cheliabinsk Metallurgical Works E. Voinov and his son Volodei. Photo by V. Aleksandrov

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TO PROVIDE THE EASTERN REGIONS WITH HIGHLY EFFICIENT METHODS OF METAL PRODUCTION

The increase of our country's pig iron output to 75-85 million tons and steel to 100-120 million tons in the next 15 years, as envisaged by the Party and the Government, necessitates the construction of new metallurgical works with the most modern equipment and methods of production.

Geographical and economic conditions of the various regions of the country require an individual approach to the choice of technical equipment and the technological basis of the new works. Therefore, the peculiarities which affect the choice of method for ferrous metal processing in individual regions should be taken into account in solving the problems of a prospective development of the ferrous industry.

The investigations carried out by a group of scientific co-workers of the New Coal and Metallurgical Centers Section of the Council for the Study of Productive Capacities of theAcad. Sci. USSR, led by Prof. A. E. Probst (Dr. of Econ. Sci.), showed that for certain regions of West Siberia and the Far East it is economically expedient to develop the electric blast-furnace production of pig iron, the manufacture of steel by the duplex process (converter – electric furnace) and the production of ordinary carbon steel in a converter with the application of oxygen blast. It was established by calculations that, as a result of savings (mainly on electric power costs) and of the higher selling price of by-products (gases), the cost of pig iron produced in electric furnaces in these regions is 20-35% lower than compared with ordinary blast-furnace pig iron. This difference in cost will make it possible to make up for the higher capital expenditure necessary for the establishment of an electric pig iron industry.

The adoption, in West Siberia and the Far East, of this new method of pig iron production in our metallurgical practice will substantially increase the operating efficiency in pig iron production processes (mainly on account of the reduction in labor requirements in fuel and power branches), and this factor is especially important for the regions where there is a shortage of manpower.

Extensive possibilities of using cheap hydroelectric power for the metallurgical processes in the East make the introduction of new steelmaking methods imperative. In this connection, the duplex process (converter—electric furnace) has very promising prospects; in this process the unwanted impurities are removed from the metal on blasting with oxygen in relatively inexpensive and very efficient equipment (converters) andthe half-product obtained is brought to the required composition in electric steelmaking furnaces. The duplex process (converter–electric furnace) will make it possible to increase rapidly the output of electric furnaces and thus provide conditions for improving the technical and economical indices of steel production by electricity.

The cost of steel produced by the duplex process in comparable conditions is approximately the same as of open-hearth steel, but better quality electrically produced steel would contribute to additional economic advantages of the duplex process.

The combination of electric steelmaking with the production of pig iron in electric furnaces is economically expedient for several regions of West Siberia and the Far East. The comparable calculations carried out, show adequately that the cost of 1 ton of electrically produced steel made from pig iron produced in electric furnaces under the conditions which obtain in some regions of West Siberia and the Far East should be, on average, 15-20% lower than the cost of open-hearth steel from ordinary blast-furnace pig iron.

Establishing the electrometallurgical ferrous industry should be closely linked with the development program of the extremely extensive hydropower resources of West Siberia and the Far East, constituting 60% of the country's total hydropower resources which can be utilized. In those regions, several large hydropower stations can be built which would supply an enormous quantity of electric energy. The harnessing of Angara and Enisei rivers alone could provide more than 200 billion kw-hr annually.

As a rule, the construction of hydropower stations has a wide complex significance involving not only the supply of electric power but also the solution of such problems as the control of the river flow, the water supply, the improvement of transport and communication, the fight against floods etc. In particular, the hydropower projects of the Far East, (especially those of the Amur basin) should play an important part as the main factors in the combating of floods which cause a loss of many millions to national economy. In this connection, one of the first objects of hydropower construction work should be the huge Zeisk hydropower station which would supply electric energy at less than 1 kopek per 1 kw-hr.

The combination of a large amount of Zeisk cheap electric energy and the huge reserves of Gagarin iron ores provides a promising basis for the construction of the first electrometallurgical works of large capacity in the Far East.

The Bessemer converter industry offers large prospects for development. The use of a converter with the application of oxygen for metal blasting will not only provide intermediate products for electric furnaces but will also increase the output of ordinary carbon steel, not inferior in quality to open-hearth steel and cheaper in price. Furthermore, an important virtue of steelmaking in converters with the use of oxygen is the fact that it affords the possibility of processing the pig iron not suitable for the open-hearth process (in particular phosphorus-containing pig iron).

Apart from making possible the extension of iron ore utilization, the converter process of phosphorus pig iron (e.g., from Lisakovsk, Aiatskoe and Kolpashevo ores) will solve Siberia's very important problem of supplying agriculture with high quality phosphorus fertilizers.

The great importance for national economy of the above methods of pig iron and steel production in the eastern regions of the country means that these methods should be tested on a semi-industrial scale without delay.

The completion of these investigations as well as the necessary design and constructional work, and the subsequent adoption of the new methods of pig iron and steel production at the metallurgical establishments in the East will contribute to further technical progress of the ferrous industry which constitutes a basis for the industrial development of national economy.

BLAST-FURNACE PRODUCTION

PRODUCTION OF SINTER BY MEANS OF THE GAS SINTERING METHOD

A. K. Rudkov

Head of the Sinter Plant of the Dzerzhinsk Works

The essential aspect of the gas sintering method is the charging of the material, prepared as for the ordinary sintering process but containing a smaller amount of carbon, on to the sinter chain. The charge is ignited with blast-furnace gas as in the ordinary process and to prevent the combustion of the reducible mixture of blast-furnace gas and air, the flame on the surface of the charge is damped with air-water jets. Special burners (Fig. 1) are employed for the gas mixture. The mixture penetrates through the layer of the charge and by burning inside it, establishes a temperature sufficient for sintering the material.

One of the machines of the sintering plant adapted for gas sintering at our works is equipped with 11 metal-constructed burners which deliver the mixture of blast-furnace gas and air into the charge layer (Fig. 2).

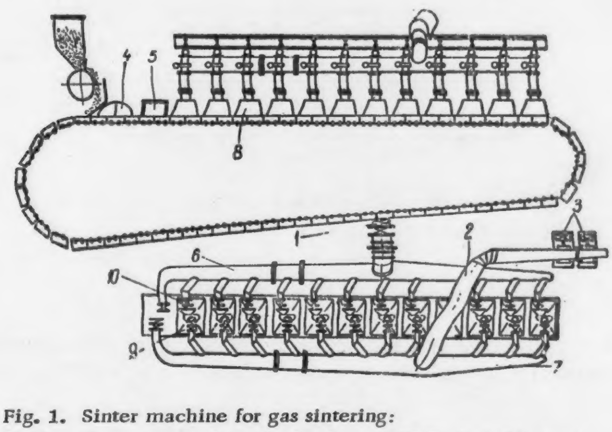

Fig. 1. Sinter machine for gas sintering:
1) blast-furnace gas pipe; 2) air pipe; 3) VVD-9 air blowers; 4) ignition furnace; 5) damping mechanism; 6) blast-furnace gas manifold; 7) air manifold; 8) burner; 9) air throttle valve; 10) gas throttle valve.

Each burner has a mixing chamber for mixing gas and air; the ratio of gas to air is controlled by means of ordinary hand operated throttle valves. All 11 burners cover 44 sq. m. of the sintering area of the machine. The remaining area is designed for the ignition of the sintering charge and for its partial damping by the air-water jets. In addition to the usual control and measuring instruments the following are employed in the gas sintering process: an automatic gas and air pressure regulator for maintaining a constant gas pressure in the gas main before the burners; instruments metering the gas and air input; manometers for gas and air pressure measurement on each burner; manometers for measuring the vacuum between the burners and the surface of the charge on the pallets of the sinter chain.

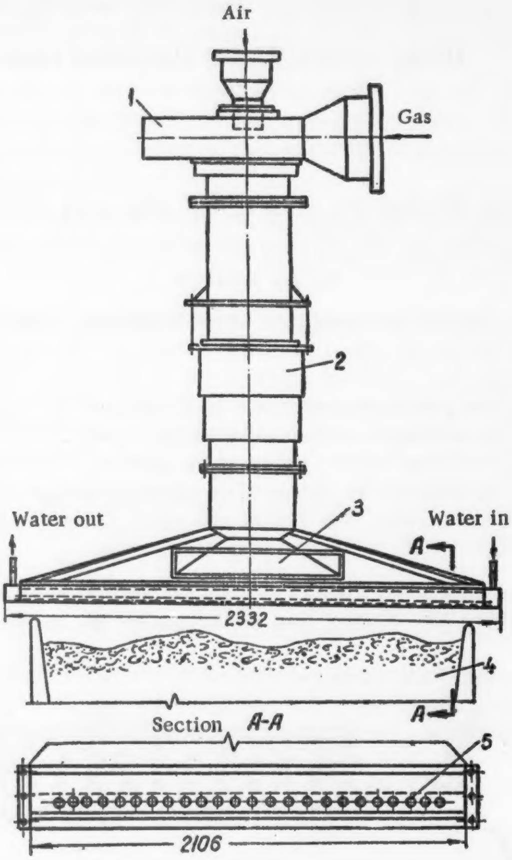

Fig. 2. Flameless burner for the delivery of the mixture of blast-furnace gas and air into the charge:
1) mixer; 2) mixing tube; 3) safety valve; 4) charge; 5) water tubes.

The charge for gas sintering was not different from ordinary charge for the Bessemer sinter. Each component was proportioned by means of a proportioning table and accurate check weighing. The composition of the charge is given in the table.

The charge was mixed in two stages: first, in the drum mixer without water and then in the pug mill with the addition of water. Samples were taken every hour for the determination of carbon and moisture. Carbon content in the charge varied from 1.6 to 2.5% and moisture content – from 5 to 5.5%. Experience showed that the optimum carbon content in the charge for gas sintering is 1.6-2%. Moisture content in the charge of that composition should be not less than 5.5-6.5%.

Composition of the Sinter Charge

Component	Amount, %	Fe content, %	SiO_2 content, %
Bessemer sinter ore	57.44	59.44	11.71
Blast-furnace dust	6.50	40.26	12.85
Limestone	6.50	–	2.8
Return fines	27.44	–	–
Coke fines	2.12	–	–

The rarefaction in the process of sintering was attained by means of an exhausting fan of 3500 cu m/min capacity and the vacuum established was 1000 mm of water. The thickness of the layer was 185-200 mm; the charge was ignited with blast-furnace gas at 1000°C. At a low content of coke fines, this temperature was not adequate for ensuring a satisfactory surface of the sintered cake. There was an unsintered layer 7-15 mm deep on the surface of the cake. It may be assumed that at an ignition temperature increased to 1250-1300°C this layer would not form.

The surface of the charge was damped immediately after the furnace. The arrangement for damping consisted of 30 jets, placed in such a manner as to damp 2 sq. m area (1 m long and 2 m wide). Water which enters the jets is sprayed by compressed air and damps only the surface of the cake in order not to allow incandescent particles of the charge on the surface. If such particles remained, the gas mixture in the first and then in the following burners could ignite.

The vacuum in the vacuum chambers on sintering the charge constituted:

Vacuum chamber	1	2	3	4	5	6	7	8	9	10	11	12	13
Vacumm, mm	500	800	900	900	900	900	900	900	900	900	900	850	800

Gas and air pressure was 300 mm and was automatically maintained by the pressure regulator. The required volumetric ratio of the blast-furnace gas and air was controlled manually with throttle valves. During the sintering, the ratio of the amount of blast-furnace gas to the amount of air was maintained at about 1 : 1.15. However, because of an unsteady gas pressure in the gas mains of the Works this ratio was sometimes upset.

The amount of the input of gas and air mixture into each burner was adjusted according to the readings of the manometers indicating the vacuum between the burner and the charge layer passing under it. The vacuum depends on the permeability of the charge and the variation in the permeability requires a change in the quantity of air delivered to the burner. A maximum quantity of gas-air mixture should be allowed through each burner. The input of blast-furnace gas through all burners operating simultaneously amounted to 6-9 thousand cu m of blast-furnace gas per hour. On several occasions the gas mixture ignited under all the gas burners at the same time. In such cases the gas was switched off at each burner and the process started again.

The content of carbon monoxide in the gas removed through the vacuum chambers is only slightly increased, compared with the ordinary sintering process. This is an indication that, as a rule, the gas passing though the charge is almost completely burnt in the charge layer. Sintering by the gas sintering method was carried out during a morning shift in 5-6 hours. During industrial-scale tests, 1200 tons of sinter was produced. Mean hourly output of the sinter machine was 45 tons; during some periods it exceeded 60 tons. In the evaluation of the experimental results, it should be taken into account that the maximum output of the sinter chain was not attained, as the ignition of gas in the burners caused unproductive stoppages and loss of output. The design of the burners and the technology of the sintering operation were very imperfect, thus limiting again the efficiency of the sinter machine.

In its outward appearance the sinter produced by the gas sintering method differs from the ordinary sinter in having a more uniform porosity and smaller size pores compared with ordinary sinter. This is explained by a reduced content of fuel in the charge.

Chemical composition of the sinter, %

Fe	FeO	Mn	SiO_2	CaO
55.90	4.73	0.16	11.40	6.90

From the composition of the sinter it is seen that its FeO content is low. Thus its reducibility is enhanced. While the sinter produced by ordinary method and containing 10% FeO is reduced 52% in a stream of hydrogen, the sinter obtained by the gas sintering method and containing 4.7% FeO is reduced 62.4% in the same period of time.

The yield of 0-5 mm fraction after testing in the drum sometimes reaches 30-35% in the case of sinter produced by the gas sintering method, while in the ordinary sinter this fraction does not exceed 27%. Thus, the strength of the sinter produced by the gas sintering method is somewhat lower than that of the ordinary sinter but only to such an extent that it does not affect the course of the blast-furnace process.

Preliminary calculations of the production cost of the gas sinter process show that if the output of the sinter in the gas sinter process is the same as in the ordinary process, all production costs, except fuel consumption, are the same for both sintering methods.

In the gas sintering process solid fuel consumption is halved but gas consumption is increased. Hence, the economy of the gas sintering process depends on the actual conditions at a given works, i.e., on the cost of blast-furnace gas as compared with the cost of coke fines and on the availability of the blast-furnace gas.

Calculations indicate that, at the Dzerzhinsk Works, the cost of sinter produced by the gas sintering method is slightly higher. It is, however, compensated by an increased reducibility of the sinter and hence a possible saving of coke in the blast-furnace operation.

BLAST-FURNACE OPERATION AT TOP GAS PRESSURE ABOVE 1 ATMOSPHERE

Candidates of Tech. Sci. V. P. Onoprienko and B. N. Starshinov

Engineers P. G. Netrebko, D. S. Ialovoi and G. V. Rabinovich

Ukrainian Institute of Metals and the "Krivorozhstal" Works

During the months March to October, 1956, blast furnace No. 3 of the "Krivorozhstal" Works was producing casting pig iron of the following composition:

Si	Mn	P	S
2.3-2.75	0.70-0.80	0.09-0.11	0.28-0.031

The basicity of the slag was within the limits of 1.12 to 1.21.

The iron ore portion of the charge contained 96.7-100% of sinter of 0.61-0.65 basicity. The input of manganese ore did not exceed 14 kg per 1 ton of pig iron.

In March, the furnace was operated at 0.46 atm gas pressure in the top and 1.51 atm blast pressure, the blast input being 2437 cu m/min. In May, the top gas pressure was increased to 0.71 atm in July, – to 1.05 atm and in August, – to 1.13 atm.

The operating data are given in the Table.

Blast-Furnace Operation at Increased Pressure

Month	Blast		Blast-furnace gas				Pressure drop in the furnace, atm.	Output, tons / 24 hours	Coefficient of working volume utilization, cu m/t*	Dust yield, kg/t of pig iron	Coke consumption t/t of pig iron	Slag yield kg/t of pig iron	Amount of sinter in the charge, %	Mean content of Fe in iron ore portion of the charge, %
	pressure, atm.	tempera-ture, °C	pressure, atm.	tempera-ture, °C	composition %									
					CO_2	CO								
March	1.51	848	0.46	464	11.5	28.8	1.05	1522.3	0.792	98.5	0.868	627	99.3	56.97
May	1.75	864	0.71	439	11.7	28.7	1.04	1507.6	0.799	51.8	0.825	630	100.0	56.53
July	1.91	880	1.05	430	12.8	27.0	0.86	1555.8	0.775	40.1	0.805	631	96.7	56.23
August	2.00	900	1.13	465	12.2	28.2	0.87	1522.7	0.791	35.3	0.819	635	96.9	56.06
September	1.93	899	1.00	428	11.5	29.0	0.93	1576.7	0.764	24.8	0.843	667	99.7	55.49
October	1.81	900	0.80	389	11.1	29.4	1.01	1530.9	0.787	33.7	0.862	662	100.0	55.03

* Recalculated on the basis of conversion pig iron.

As is seen from the table, the increase in the pressure of the blast-furnace gases was accompanied by a reduction in the amount of blast-furnace dust and in the consumption of coke. Also, the pressure drop over the section from the hot blast to the furnace throat decreased. When the gas pressure was increased, the temperature of the blast was raised. This resulted in an improved utilization of the gas stream, as is seen from the change in the CO_2 content in the gas. All the changes of operating conditions allowed an increase in the ore burden and a high output of the furnace.

In the course of the period under consideration the iron content in the charge was falling. Therefore, for an objective evaluation of the effect of the adoption of a higher pressure, the recalculations of the main operating indices of the blast furnace were carried out on the basis of the content of iron in the charge. It was established that when the top pressure was raised from 0.46-0.71 to 1-1.05 atm, the output of the furnace increased by 4-7% and coke consumption by 5-9%.

In conclusion it should be pointed out that at an increased top gas pressure the peripheral gas flow develops very markedly. Hence, for a better utilization of gas energy the weight of the coke charge should be reduced (in our case the coke charge was reduced from 6.3-6.45 tons to 5.6 tons) and the furnace charging should be: coke-coke-ore-x-coke-limestone-x and coke-ore-x-coke-coke-limestone-x.

As a result of the reduction in the velocity of the gases, the blast temperature could be raised by 50°C.

CONTROL OF THE BLAST-FURNACE PROCESS BY MEANS OF RADIOACTIVE ISOTOPES*

V. A. Smoliak and V. N. Uzliuk

Dnepropetrovsk Metallurgical Institute and Central Works Laboratory of the Dzerzhinsk Works

The application of isotopes in ferrous metallurgy opens new possibilities for studies and improvements of the technology of the blast furnace process. At present, radioactive isotopes are used for testing the refractory lining of the blast furnace, for investigating the movement of charge materials and gases and for the study of pig iron mixing processes in the hearth.

This article describes the application of isotopes in the study of movement and the carry-out of the fine fractions of the charge and in the measurements of the level of the products in the hearth of the blast furnace.

Study of the Movement of Fine Fractions of the Charge in the Furnace

When charge materials containing a large amount of fine fractions are smelted, the carry-out of blast-furnace dust reaches 30% of the weight of the whole iron ore portion of the charge. During the descent of the charge, additional fines are formed by the crushing of the friable components of the charge; gas permeability of the charge decreases and normal operation of the furnace is made difficult.

The study of the movement and carry-out of fine fractions of iron ore, sinter and manganese ore was carried out in a blast furnace equipped with special instruments and attachments for the introduction of radioactive dust material into the stock in the furnace. The diagram of the testing arrangements is shown in Fig. 1. For the measurements of the radiation intensity and the detection of the radioactivity, counters were installed in two gas uptakes of the blast furnace; the counters were placed in thin-walled cooled tubes built into the gas uptake on the level of the furnace-top platform (Fig. 2).

For the registration of radioactivity in the dustcatchers, counters were installed at the pug mills. Radiometric equipment was placed in the control room of the blast furnace.

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* The investigation was carried out under the supervision of Doctor of Tech. Sci., Prof. A. D. Gotlib.

Radioactive dust fractions were introduced, using special gas-sampling probes, into the furnace charge at points 300, 600, 900, 1200, 1500, 1800, 2100, 2400 and 2700 mm from the furnace lining. For the investigation of the movement and carry-out of fine charge fractions, radioactive isotopes of iron ascorbate and metallic tantalum in the form of grains divided into 0.2-5 g portions of 5-15 millicurie specific radioactivity were used. These isotopes have highly penetrating hard gamma-rays radiation.

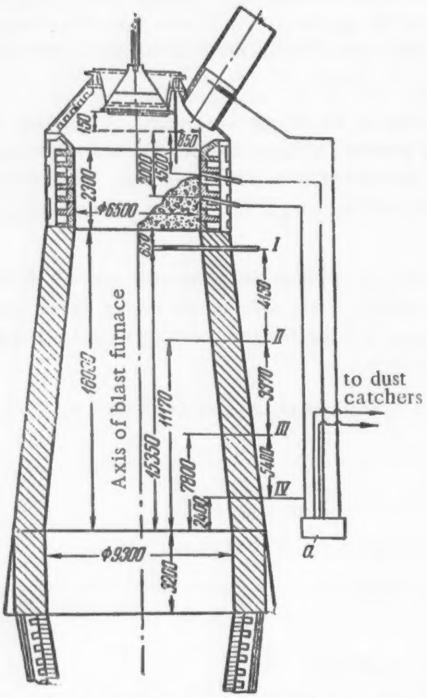


Fig. 1. Diagram of the arrangement for the radiometric equipment of the blast furnace: a) apparatus for pulse counting; I-IV) level numbers.

The grains of radioactive isotopes were mixed with 15-25 g of fine ore or blast-furnace dust, wrapped in canvas bags and pushed by means of special probes into the charge in the working volume of the furnace. In addition, unwrapped portions of activated dust were added into the skip with lumpy materials in such a manner that the portions fell into the receiving hopper at various stages of the transfer of the materials from the skip. Such a method of introduction of isotopes with the charge through the charging apparatus made it possible to study the conditions of dust carry-out during the descent of the batch from the large bell. The position of the rotary distributor was selected in such a manner that the charge with the isotope got into the investigated sector of the furnace in the region above tuyeres Nos. 8, 9 and 10.

Counters were placed between the guard ring of the stack in cooled tubes and they served for the detection of radioactivity above the stock line, when the stock line level descended below two meters. The tests were carried out during the normal operation of the furnace, the charge containing 80% sinter. In the evaluation of the experimental results the scheme of charging, granular size of charging material, level of the stock line, content of carbon dioxide in the gas along the radius of the stock, velocity of the descent of the charge, gas temperature in the gas offtake and the thermal and blast operating conditions were taken into account. All these factors completely characterized the distribution of the gas flow through the cross section of the furnace and made it possible to conclude that there was no channeling.

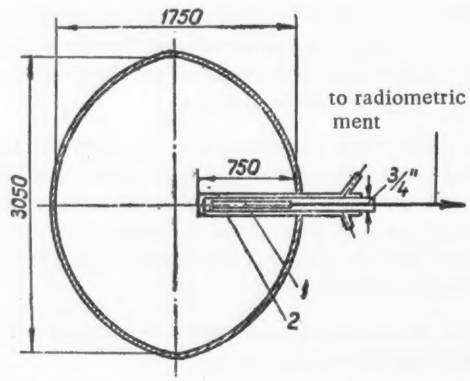


Fig. 2. Pulse counter mounted in the gas uptake: 1) counter; 2) photographic film.

The particle size and the weight of the isotopes employed allowed for the investigation of the movement and carry-out of the charge fractions of sizes from 0.25 to 1.7 mm along the radii and the height of the charge and the stack.

As a result of the investigations carried out, it was established that the dust fractions 0-1.7 mm of the charge materials are intensively carried off by the gas stream at high velocities (up to 15 m/sec) not only from the surface of the stock and above it but also from the deep layers of the charge. Radioactive metallic tantalum filings of 0.6 mm size were carried out from the IVth level of the charge from the points situated 300-400 mm from the furnace lining. Fine fractions of the charge (up to 1.7 mm) are carried out of the periphery and the central part of the furnace and this fact excludes, in our opinion, the transfer of the ore from the periphery to the central part, causing the overloading of the furnace center with the fine fraction ore.*

Measurements of the Level of the Products in the Hearth

In connection with the intensification of the blast-furnace process and the introduction of advanced technology of pig iron production (pressure operation, use of sinter, oxygen-enriched blast) the problems of accumulation of the products in the hearth become very important. Knowing the level of the slag in the hearth, the operating personnel of the blast furnace can arrange a regular removal of the slags and prevent the slag from getting into the tuyeres and nozzles during accidental stoppages of the furnace.

A new method of checking the slag level in the hearth by means of radioactive isotopes was tested at the Dzerzhinsk Works.

Radioactive isotopes of cobalt-60 of 200 millicurie, fixed on long rods with lead screens, were permanently fitted into thin cooled tubes in tapholes No. 1 and No. 2, welded into the recesses for water circulation in the air and slag tuyeres (Fig. 3). Counters in cooled tubes were placed in the tuyeres situated above the slag notches. The counters were connected with the scaler.

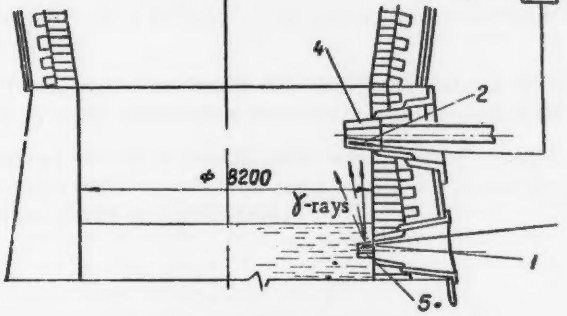


Fig. 3. Emitter and counter in the blast furnace:
1) emitter; 2) counter; 3) scaler; 4) air tuyere; 5) slag notch.

The intensity of the radiation recorded by the counter depends on the height of the slag and coke layers in the path of the beam of rays between the slag notch and the air tuyere. With the rise of the slag level in the hearth, the absorption of the radiation increases and its intensity decreases. With the increase in the slag layer thickness, the intensity of the radiation decreases in accordance with a strictly determined law.

For each slag notch and air tuyere pair with emitter and counter, a calibration table was established from the experimental data and the table was used to determine the level of the products in the hearth.

On the removal of the slag through notch No. 2, the intensity of radiation in the region of notch No. 1 increased. Hence, it is seen that the radiometric method of slag level determination in two slag notches gives an indication of the slag level over the whole cross section of the hearth.

* These conclusions of the authors are not confirmed by other investigators. Editor.

Dependence of the Intensity of Radiation on the Thickness of the Slag Layer in the Hearth

Height of the slag level in the hearth from the center of slag notch No. 1, mm	Intensity, pulse per minute, of γ-radiation of cobalt-60 of radioactivity, millicurie		
	300	250	100
900	25	22	2
800	150	27	5
700	300	98	14
600	465	200	36
500	600	300	56
400	765	410	74
300	890	508	86
200	1050	605	102
100	1150	720	116
0	1235	830	128

There is no radiocontamination of the blast-furnace products by the isotopes placed in the slag notches. Monitoring of the personnel exposed to radiation showed that the operating personnel at the slag notch are not affected by radiation.

A considerable disadvantage of the proposed method is the bulky equipment of the scaler. It is essential to design a portable apparatus for an automatic measurement of the slag level in the hearth.

The installation of the radiometric tubes does not impair the cooling of the tuyeres. Appropriate tuyeres can be made in the machine shop of the blast-furnace plant.

The method of the determination of the slag level in the hearth described above can be recommended for commercial use.

MECHANICAL UNLOADING OF CARS

A. T. Popov

At the Zakavkaz Metallurgical Works, the flat cars with lightweight scrap delivered from scrap and rolling plants are unloaded by means of an electro-magnetic crane. This method requires a large input of electric power; the depreciation of the equipment is very high and the operations are very slow.

With the object of eliminating these disadvantages, the author proposed a self-unloading car which can be used for transportation of lightweight scrap (iron, tubing and plate trimmings), as well as for sand, lime, brick rubble, etc.

The design of the car is fairly simple: the bottom of the ordinary car is taken out and used for making three containers. The containers are fixed on one side on the hinge attached to the car frame, and on the other they have lugs for the hooks suspended on the cable. Another hook at the other end of the cable is attached to an electro-magnetic crane. When the crane rises, the container turns on its hinge and the material falls out of the container. The containers can be turned through 50-60°. The remaining two containers mounted on the car frame are tipped in the same manner.

The sides of the flat car are made of girders. On the cars for the transportation of tube pieces, the sides are extended with iron plate cuttings.

Cars with three pairs of containers which can be unloaded on both sides of the railroad track by the bridge crane and are used on the gantry of the blast-furnace plant and in other sections of the works.

The adoption of tipping cars resulted in a considerable reduction of unloading time (a 60 ton car is unloaded in 2-3 minutes), complete elimination of manual labor and a large saving of electric power on account of a marked reduction in the operation of the electro-magnetic crane.

STEEL SMELTING

PRODUCTION OF LOW-CARBON STEEL IN OPEN-HEARTH FURNACES

A. A. Kiselev

"Krasnyi Oktiabr' " Works

Bimetallic steel-aluminum bar, instead of the previously employed lead bronze, is used for the main and connecting rod bearings of the crankshaft in tractor motors DT-54 and KD-35. The bar is made by cold rolling of the packet consisting of pieces of low-carbon steel (Armco iron type) and ASM alloy.

The chemical composition of low-carbon steel (Armco iron type) is % (not more than):

C	Mn	Si	S	P	Cu	Cr	Ni
0.04	0.20	0.20	0.030	0.025	0.15	0.15	0.15

The ASM alloy contains 3.5-5.5% Sb, 0.3-0.7% Mg and the remainder is aluminum.

The production of low-carbon steel (Armco iron type) for the bimetal involves several specific difficulties during the steelmaking process in the open-hearth furnace as well as during the subsequent treatment. The oxidation of carbon down to a low concentration is difficult in open-hearth furnaces; high oxidation of slag and metal causes considerable damage to the lining of the furnace and impedes the process of sulfur removal. There are frequent cases of partial transfer of sulfur from slag into metal.

The high oxygen content in low-carbon steel and the sulfur content exceeding the limit of sulfur solubility in solid iron contributes to the formation of seams and cracks on ingots and billets in the course of rolling.

When the production of low-carbon steel was first introduced, an additional deoxidation of metal with silicon and manganese was not applied; the billet rolled from that metal exhibited fractures and cracks. More extensive deoxidation of steel was carried out in order to eliminate these defects: before tapping, the metal in the furnace was treated with aluminum (500-600 g/tons of steel); in the ladle, metal was deoxidized with 15% ferrosilicon and metallic manganese in such an amount as to ensure a silicon and manganese content in the final steel of not less than 0.15%, and with the original aluminum to the amount of 1600-2000 g/ton of steel. As a rule, the metal was poured under the conditions of "clear mirror."

Steel of the Armco iron type was produced by the above method in the course of 1956. Cases of unsatisfactory rolling of the ingots were brought to a minimum. However, on the bimetallic bars, from the metal of some heats, seams were observed. A statistical analysis of 24 heats showed that seam formation on bimetallic pieces occurs on the metal from heats carried out under the following conditions:

a) increased carbon content after melting (0.90% C compared with 0.75% in the heats without seams);

b) increased ferrous oxide content in the slag before discharge (14.0% instead of 0.75%);

c) reduced rate of carbon removal during the last 60 min of the refining period (0.0006 instead of 0.0011% C per minute);

d) increased aluminum and silicon content in the finished steel (0.030% Al instead of 0.0015% and 0.165% Si instead of 0.135%);

e) lower temperature for pouring of steel into molds;

f) reduced loss of silicon (32.5 instead of 49%);

g) steel was produced in furnaces of smaller thermal capacity.

In addition, it was established that seam formation on bimetallic bars depends on the degree of metal deoxidation; the higher the degree of deoxidation the greater the probability of seam formation.

Starting in April, 1957, the following changes were introduced into the method of low-carbon steel (Armco iron type) production:

Carbon content, % (not more than); before the melting period 0.75, before the deoxidation period 0.040.

FeO content in the third slag not less than 15.0%.

Commencement of the boil period at not more than 0.35% carbon content.

Rate of carbon removal during the last 60 minutes of the refining period not less than 0.0008% C per hour.

Pouring of steel under the conditions of clear mirror through the whole height of the mold or not less than 2/3 of the mold height.

Al content in finished steel not more than 0.005%.

25 heats were carried out in accordance with the method under test. In order to ensure a high rate of carbon removal in the last period of refining after the sulfur content fell below the permissible level, iron ore in the amount of 1000-2000 kg for a 50 ton heat was introduced into the bath by means of a charging box. In the majority of the heats, simultaneously with the introduction of iron ore, the bath was blown through with compressed air.

Prior to tapping, the metal in the furnace was deoxidized ("washed") with aluminum to the amount of 300-500 g/ton of steel, and in the ladle – with primary aluminum to the amount of 1200-1500 g/ton, 75% ferrosilicon and metallic manganese.

Seams on the bimetallic bar were detected only on the metal for two out of 25 experimental heats. Significant features of the heats in which the metal exhibited seams, was a lower temperature during pouring, high aluminum content in the finished metal (0.014 and 0.016%) and carbon content of steel in the upper limit (0.04%).

After rolling in the blooming mill, the ingots from two out of 25 experimental heats exhibited fractures and cracks; the billets from six heats exhibited minor fractures and cracks. The heats from which ingots exhibited defects after rolling were distinguished by an increased oxidation of the metal indicated by a high content of FeO in the slag before tapping (26% compared with 22% in satisfactory heats), and an increased silicon loss (51% compared with 42.5%).

At present, the method of low-carbon steel (Armco iron type) production in the open-hearth furnaces of the "Krosnyi Oktiabr' " Works is strictly laid down and includes the following main principles.

Steel is made only in the furnaces of large thermal capacity. The carbon content in the metal after melting should be within the limits of 0.25-0.70%. The rate of carbon oxidation at the end of the refining period should not be below 0.0008% C per minute, and therefore when the carbon content is 0.07% or less, 1000-2000 kg of iron ore for a 50 ton heat is introduced into the bath. The ferrous oxide content in slag before tapping should be within the limits of 18-30%; metal in the ladle is deoxidized with aluminum to the amount of 1400-1700 g/ton of steel. Silicon and manganese content in finished steel should not be less than 0.13%; steel is poured into molds under the conditions of "clear mirror."

The billets from the roughing mill are suitable for further processing into bimetallic bars provided that the aluminum content in the steel does not exceed 0.005%. If the aluminum content in the steel is within 0.006-0.010%, only one ton of blooms is rolled into plate in order to test whether the steel is suitable for the manufacture of bimetallic bars. If the results are satisfactory and the steel adheres well to the ASM alloy, all the ingots from that heat are used for the production of bimetallic bar; otherwise, the ingots are used for other purposes.

The introduction of the above method ensures a stable mass production of bimetallic bar and the elimination of defective product due to seam formation.

USE OF MANGANESE ORE IN SCRAP-PROCESS STEELMAKING

V. M. Soifer

Briansk Machine Works

When low-manganese conversion pig iron is used in the scrap process in the open-hearth furnaces, the content of manganese is lower than in the case of pig iron with high manganese content. Hence, more ferromanganese must be used to bring the manganese content in steel to the required level.

Thus, when steel for castings was made from manganese-containing pig iron in 20 ton basic furnaces at the Briansk Machine Works, the consumption of ferromanganese constituted 10 kg/ton, and when low-manganese pig iron was employed ferromanganese consumption increased to 12-13 kg/ton.

Since 1956, with the object of reducing ferromanganese consumption, manganese ore is added into the furnace to the amount of 1% of the weight of the metal portion in the charge. The materials are charged into the furnace in the following manner: first, light-weight scrap, then limestone (6% by weight of the charge), manganese ore (Nikopol ore containing 45-55% Mn and 5-8% SiO_2) and then the remaining scrap and conversion pig iron.

After the charge is melted, the slag is partially removed. As the metal is heated, manganese is reduced and passes from the slag into the metal. As is seen from Table 1, the addition of manganese ore ensures a higher manganese content before the deoxidation. Therefore, there is no increase in ferromanganese consumption when low-manganese pig iron is employed.

TABLE 1

Effect of Manganese Ore Addition on the Manganese Content in Steel

Manganese in conversion pig iron, %	Description of heat	Number of heats	Mean manganese before deoxidation, %
1.5-2.5	Without manganese ore	136	0.33
0.5-0.8	Without manganese ore	164	0.22
0.5—0.8	With manganese ore	11	0.30

TABLE 2

Description of Heats

Item	Heats without manganese	Heats with manganese
Number of heats	404	400
Mean melting period, hr-min	2-43	2-29
Mean carbon content after melting, %	1.29	1.40
Mean rate of carbon oxidation during boil, % C/hr	0.58	0.63
Mean duration of heat, hr-min	6-44	6-18

Note. Limestone was added in each heat to the amount of 6% by weight of the charge.

Several works do not use manganese ore additions because of the opinion that they would prolong the melting period. The investigations of this problem at our works, carried out with pig iron containing 1.5-2.5% Mn, showed that the addition of manganese ore to the charge does not prolong the melting period but on the

TABLE 3

Chemical Composition of the Slag After Melting, %

Description of heat	SiO_2	FeO	MnO	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5
Heats with manganese ore	30.80	5.55	16.02	2.50	2.10	33.25	9.00	0.604
	32.90	4.15	13.60	0.90	1.32	36.10	10.50	0.210
	33.90	8.00	15.80	1.80	1.31	31.20	7.30	0.580
	22.30	15.10	19.80	2.40	2.40	28.40	8.30	1.210
	24.10	12.50	15.60	2.50	1.40	30.50	10.50	1.040
	33.00	5.10	17.10	1.35	2.50	31.20	10.30	0.650
	28.30	8.70	15.30	3.40	1.40	30.60	11.60	1.010
	31.00	10.10	14.00	1.13	1.48	29.50	11.42	1.050
	30.22	6.57	14.79	1.70	1.24	31.25	11.85	0.795
	32.00	6.40	15.30	0.90	2.90	31.80	10.90	0.850
mean content	29.85	8.22	15.73	1.77	1.80	31.38	10.17	0.800
Heats without manganese ore	32.50	9.20	11.77	1.80	2.39	33.00	9.52	1.130
	30.50	5.10	13.00	1.20	2.40	36.60	0.40	0.620
	29.30	6.80	12.80	1.35	2.80	37.80	8.50	0.987
	29.10	10.91	13.27	1.67	1.40	33.69	6.88	1.510
	30.00	10.26	9.25	1.98	2.35	36.00	10.05	0.940
	26.50	14.00	7.60	1.50	2.25	32.00	15.30	0.640
	28.48	10.83	14.48	1.72	2.35	30.45	10.33	1.050
	31.00	7.60	15.10	1.50	1.70	35.20	6.90	0.710
	33.34	6.00	13.00	1.27	1.25	36.50	7.00	0.630
mean content	30.0	8.96	12.25	1.56	2.10	34.50	9.62	0.910

contrary even reduces it. It is seen from Table 2, where the statistics of the experimental results from more than 800 heats are given, that for the heats carried out with the addition of manganese ore to the charge, the duration of the melting period is on the average 14 minutes shorter than for the heats without manganese ore additions. The addition of manganese ore resulted in a reduction of melting period by 8.6%.

It is known that the velocity of slag formation substantially affects the length of the melting period. At the beginning of the melting period the slag is formed mainly on account of the oxidation of the elements – iron silicon and manganese – in the charge. When a certain temperature is reached the decomposition of the limestone takes place and lumps of lime float up into the slag (so called "lime boil"). Frequently, in steelmaking practice, the melting period is considered finished only after the cessation of the lime boil, although this process may end sometimes after the metal portion of the charge has been melted. The rate of slag formation and, hence, the length of the melting period depends to a great extent on the quantity, composition and distribution of the slag-forming materials in the charge.

Several authors give data showing that the introduction of additional amounts of some slag-forming materials into the charge at an unchanged amount of the limestone assists in speeding up the process of slag formation and in reducing the length of the melting period.

It is seen from Table 3 that the slag after the melting period in the heats with manganese ore contained, on the average, 15.73% MnO and 31.38% CaO, and in the heats without manganese ore – 12.25% MnO and 34.5% CaO. The mean content of the remaining components of the slag is approximately the same for both groups of heats. Thus, as a result of the introduction of manganese ore into the charge, a partial substitution of CaO by MnO in the slag takes place. It should be assumed that such a substitution causes a speeded-up slag formation during the melting period.

The data in Table 2 show that the heats carried out with the addition of manganese ore into the charge had a higher carbon content after the melting period. This, apparently, can be explained by the shorter melting period, as the composition of all heats under test was constant: 42% conversion pig iron of approximately the same chemical composition in all heats, and 58% steel scrap – waste of the same type from foundry , forge and mechanical plants.

From Table 2 it is also seen that in spite of a higher carbon content after the melting period, the mean length of heats with manganese ore addition is shorter than of heats without manganese ore. This is explained, apart from the reduction in the melting period, by the fact that the rate of carbon oxidation during the period of pure boil is higher in the heats with manganese ore, because the increased MnO content in slag constitutes an additional source of oxygen for carbon oxidation.

The introduction of manganese ore into the charge is extensively practiced at our works and is now included in the works' instructions on steelmaking.

From the experience of the Briansk Works the following conclusions can be drawn.

With the object of saving ferromanganese in steel production from low-manganese pig iron by the scrap process in basic open-hearth furnaces, it is expedient to introduce manganese ore into the charge to the amount of about 1% by weight of the charge. The length of the melting period and the total duration of the heat is reduced; the carbon content after the melting period and the speed of decarbonization during the period of clear boil are increased.

INCREASING THE DURABILITY OF THE HEARTH IN OPEN-HEARTH FURNACES

E. G. Druzhinin

Senior Foreman of Open-Hearth Furnace Plant No. 1 of the "Krasnyi Oktiabr' " Works

Further improvements in the design of open-hearth furnaces, the introduction of basic refractories and improvements in thermal processes resulted in a marked increase in the durability of the upper structure of open-hearth furnaces. At the same time the durability of the sintered layer of the bottom is still inadequate and is approximately 10-15 times lower than the durability of basic roofs. Hence, the open-hearth furnaces have to be shut down periodically for repairs of the bottom. The extent of stoppages for bottom fettling varies from works to works. Very frequently, because of poor work organization, inadequate experience and other causes, the repairs of bottoms are prolonged and the output of the open-hearth furnaces falls short of target. We therefore think that more attention should be devoted in our periodicals to the problem of the maintenance of open-hearth furnace bottoms. Until now however, articles on the durability of the hearth in the journals "Metallurgist" and "Steel" have been rare.

Each works has its own method of bottom fettling and the application of some methods used at other works may give good results. Bringing our experience on furnace bottom maintenance to the attention of the readers, we appeal to senior foreman of open-hearth plants to write to the "Metallurgist" about their experience.

The open-hearth furnaces of plant No. 1 at our works are operated on the scrap process. Steels of various grades are produced: from carbon steel to high-alloy steels. The furnaces are fitted out with chrome-magnesite roofs and are fired with natural gas with the addition of fuel oil.

An accurate record of hot stoppages of the furnaces is kept. An extra delay of 15-20 minutes above the schedule for fettling the furnace or a prolonged tapping of metal because of the poor condition of the tapping hole, are recorded as hot stoppages.

Twenty minutes from the beginning of the steel tapping are allowed in the schedule for the preparation of the furnace. Magnesite powder is used for fettling. Because the furnace floor cranes are frequently engaged, it is not always possible to use belt-type fettling machines and the whole fettling has to be done manually. Mainly the back bank is thoroughly fettled. After the inspection of the hearth, the front banks are repaired only in places where they are worn out.

Magnesite powder is used also for drying and closing the tapping hole. In a case when the tapping hole on the furnace inside is too large it is filled with a special mixture prepared from ground magnesite and chrome-magnesite brick chippings, fire clay (10%) and water. The same mixture is used for the ramming of the hole after the repair of the bottom and for the coating of the front wall columns. The condition of the tapping hole is very important for the durability of the hearth. Very frequently the tapping hole gets "clogged" and its level rises, causing pools of metal and slag to remain in the furnace in front of the tap hole after tapping. The bottom in the tap hole has to be chipped off over most of its length. The remaining part of the hole is then burned through with oxygen or scoured.

Furnaces are shut down for bottom repair when the condition of the bottom warrants it. There is no strict schedule of furnace shut-downs for bottom repairs and this, in our opinion, has a negative effect on the durability of the bottom as well as on the length of stoppages for its repair.

After the tapping of the heat before the repairs, the ridges in the furnace are removed by means of a charging machine. Containers, usually used for the transportation of bricks during furnace repair, are placed in front of the two end doors and the middle charging door. Charging boxes are placed on the containers. A special cover with a 200×170 rectangular aperture is placed over the middle door. The preparation for blowing off the metal takes 20-30 minutes. The metal is blown out with air at 5-6 atm pressure in the mains delivered simultaneously through two or three pipes of $1\frac{1}{4}$ diameter and 7-10 m length. With two pipes, metal and slag is pushed from the slopes toward the tap hole and with the third it is blown into the tap hole. Sometimes one side (the higher one) of the furnace is cleaned first and then the other.

After the cleaning of metal and slag from the hearth, the furnace is heated for 10-15 minutes to allow the splashes of metal and slag from the banks and the walls to run down, and then the final cleaning of the hearth begins. The primary cleaning of the hearth is carried out at a small input of fuel oil (500-800 kg/hr); during the secondary, more thorough cleaning, the fuel oil is turned off. The cleaning of the bottom takes 1.5 to 2 hours.

It should be mentioned that the fixed runners for steel tapping cause a considerable difficulty during the blowing out of the metal and slag. The solidified metal and slag in the runner completely obstruct the tap hole. The skull in the runner cannot be removed with air. The cleaning of the furnace has to be interrupted until the runner is cleaned and, thus, considerable time is lost.

Great difficulties were experienced on account of the poor quality of the pipes used for the cleaning of the hearth. Often the pipes were welded from several pieces and therefore did not last for long. Furthermore, the pipes made of carbon steel burn quickly, especially during the blowing out of the metal when the furnace is operated with a hot flame. In the course of one repair of the bottom, 30-40 m of such pipes is sometimes burnt. The replacement of pipes is time-consuming. We consider that the use of fire-resistant steel pipes pipes for hearth cleaning would result in considerable savings.

After the bottom is cleaned of metal and slag, the furnace is fired at the full rate of fuel input and the fettling of the bottom with magnesite powder is commenced. First, the whole bottom is covered so that slag cannot collect. Subsequently, the banks and the back wall are fettled by means of a fettling machine, about 4 tons of magnesite powder being used for this operation. If there are no deep holes in the bottom, it is then smoothed out beginning from the middle charging door. When a normal slope is formed in front of the tap hole the fettling begins through the two next doors. Usually, the contour shaping of the bottom at the second doors is the most labor-consuming operation. A large amount of magnesite powder is required.

Subsequently, the bottom at the two outside doors is fettled. This operation requires less effort as here it is easy to level the bottom. As a rule, the fettling of the bottom takes 2-3 hours, depending on the quantity and quality of the magnesite used for fettling, the size and type of the holes in the bottom, etc. After the fettling of the bottom is finished, the front wall columns are dressed by means of a special spoon. This operation takes 20-30 minutes.

It should be pointed out that the above procedure of fettling is not always observed. Sometimes, when the bottom is extensively worn out, the front wall is dressed after the first layer of the magnesite powder has been applied and then the contour of the bottom is finally shaped. During the dressing of the front wall, the first magnesite layer is heated.

It has been pointed out above that the tap hole is filled with a special mixture. If the tap hole has been extensively eroded during the repair of the bottom, a specially prepared wooden form is laid onto the lower side of the hole and it is immediately covered with a mixture. From the other side of the furnace the first furnace assistant rams the mixture with a rabble so that the necessary size of the hole is obtained. The wooden form is ignited on the side of the runner and from the inside of the furnace a stream of hot air is directed onto it. Thus, the wooden piece burns from both sides. While the bottom is heated and dressed with slag the wood burns through. If a small piece still remains in the middle of the tap hole, it is pushed out with a crowbar and the hole is cleaned with the rabble.

If, after the furnace cleaning, the tap hole is not very large, the first assistant simply fills it with magnesite powder from the outer end, and the prepared mixture is thrown into it from the inside of the furnace. After the tap hole has been closed, the burning-in of the bottom continues. The heating lasts for 1.5-2.0 hours, depending on the quantity of magnesite powder used.

After the heating, the bottom is slagged with scale. The scale supplied usually contains a great deal of metal cuttings (up to 20 kg in weight) from rolling mill operations. It is not safe to handle such scale in charging boxes and first it has to be separated. Attempts to use the fettling machine for scale were unsuccessful because coarse scale would not pass from the bin onto the belt. Moreover, the machine can be damaged by the metal cuttings. The amount of scale used for the whole bottom constitutes about 20% by weight of the magnesite powder used. The operation takes 30-40 min.

When some slag collects on the bottom (this indicates that the whole bottom is saturated with slag) the tap hole is opened and the slag is run off. We have been using the scale for the past 6 or 8 months. Previously, open-hearth furnace slag, run off after melting into special slag pots, was used for the slagging of the bottom. The slag was broken down into lumps not more than 200 mm in size and was distributed on the bottom by means of the charging boxes and the charging machine. The amount of slag used for slagging of the bottom constituted 40-50% by weight of the magnesite powder used.

The durability of the bottom treated with slag was almost the same as that treated with scale. The preparation of slag, however, requires considerable manual labor. Moreover, the slag required for two fettlings only, took a lot of space and made a mess in the plant. Now, ground slag is used for filling large holes in the bottom. For this purpose, ground slag is mixed with magnesite powder and is thrown into the hole. Such a mixture is burned-in much more rapidly.

After the slag is run off, the fuel oil is turned off. The bottom is cooled for 20 minutes and the charging begins. As a rule, lime is initially charged onto the bottom (5 charging boxes — one for each charging door) to prevent damage to the bottom by lumps in the metallic portion of the charge. Firing then begins and the remaining materials are charged into the furnace.

On the average, the repair of the bottom takes 8 hours. Each furnace is shut down two or three times per month for bottom repair.

In some cases the fettling of the bottom is carried out in a different way from the established procedure.

1. When the bottom is extensively eroded or there is a large hole with flat edges, crushed magnesite brick chippings (20-70 mm in size) are used for the first layer. As the crushed magnesite is coarser than magnesite powder, it sinters better. During the burning-in of the first layer, the front and back walls of the furnace are dressed. After the burning in (about 1 hour), pure scale (or fine slag) is laid over the crushed magnesite. When the scale (or slag) is melted, fettling with magnesite powder is carried out. The use of crushed magnesite gives

good results and we often use it if magnesite brick rubble is available.

2. There are cases when a hole, small in diameter (up to 1 m) but deep, is eroded in the new bottom (during the second or third heat after the repair). It is not expedient in such a case to repair the whole bottom. On the other hand, filling of one hole with magnesite powder or crushed magnesite is not safe; the thick layer of magnesite will not sinter through and the layer will be torn off in the next heat. In such cases we repair the hole with ground magnesite-brick chippings mixed with water. The mass is prepared and when the metal is blown out of the hole the material is thrown into the hole either manually or by means of the charging box. As it falls into the hole, the material is closely packed and adheres tightly to the sides of the hole. The hole is then smoothed out and heated for 30 minutes. During that time the charge is delivered on to the other half of the bottom.

After the burning-in, the repaired spot is covered with scale or fine slag and, after 10 or 15 minutes, first the lime and then the scrap is charged. This method shows good results in a case of the repair of deep holes with steep sides, i.e., just when it is difficult to use magnesite powder. The repair of the bottom by this method takes 1.5-2.0 hours.

The stoppages of the furnaces in plant No. 1 for the repair of the bottom amounted to 2.43% in 1957.

Editor's note. In spite of the relatively low durability and some shortcomings in the method of repairing the open-hearth furnace bottoms at the "Krasnyi Oktiabr' " Works, the editor publishes the article by E. G. Druzhinin in the hope that operators of open-hearth furnace plants will write, in the "Metallurgist," of their experience on the fettling of the furnace bottom.

THE EFFICIENCY OF BLOWING COMPRESSED AIR INTO THE OPEN-HEARTH FURNACE BATH IN THE SCRAP PROCESS

Cand. Tech. Sci. M. Ia. Medzhibozhskii,

Engineers V. P. Tunkov and L. A. Smirnova

The Siberia Metallurgical Institute and the "Serp i Molot" Works

The blowing of compressed air into the bath of the open-hearth furnace was proposed as early as 1939. The tests carried out at that time at the "Krasnyi Oktiabr' " Works and later on at the Kuznetsk Metallurgical Combine showed that by this method the output of small furnaces (10 to 30 ton capacity) is increased by 15-20% and of larger ones (185-ton or more) by 8-10%.

The essence of the method lies in the fact that when compressed air is being blown into the liquid metal, an intensive mixing of the bath takes place which accelerates all technological processes (melting, carbon removal, slag formation, metal heating, dephosphorization, desulfurization and others). A decisive part is played by the speeding-up of the transfer of oxygen from the furnace atmosphere into the bath. The quantity of this oxygen during the blasting of the bath with air is much larger than the amount of oxygen introduced with compressed air into the metal. Therefore, at the same input and pressure of oxygen or compressed air into the open-hearth bath, approximately the same results on the speed of carbon removal and the rise of metal temperature are obtained.

When the metal is blown-through in a converter the oxidation of carbon takes place only at the expense of the oxygen of the cold air blown in, and the temperature rises only slightly because of the cooling effect of nitrogen which lowers the over-all heating effect of the reaction. In the open-hearth furnace, when the bath is blown-through with compressed air, the predominant part in the process of decarbonization is played by the oxygen from the furnace atmosphere, heated to 1700°C, and hence a rapid rise in the temperature of the metal is ensured and fuel consumption is reduced. The cooling effect of nitrogen, contained in the compressed air, is comparatively small in this case.

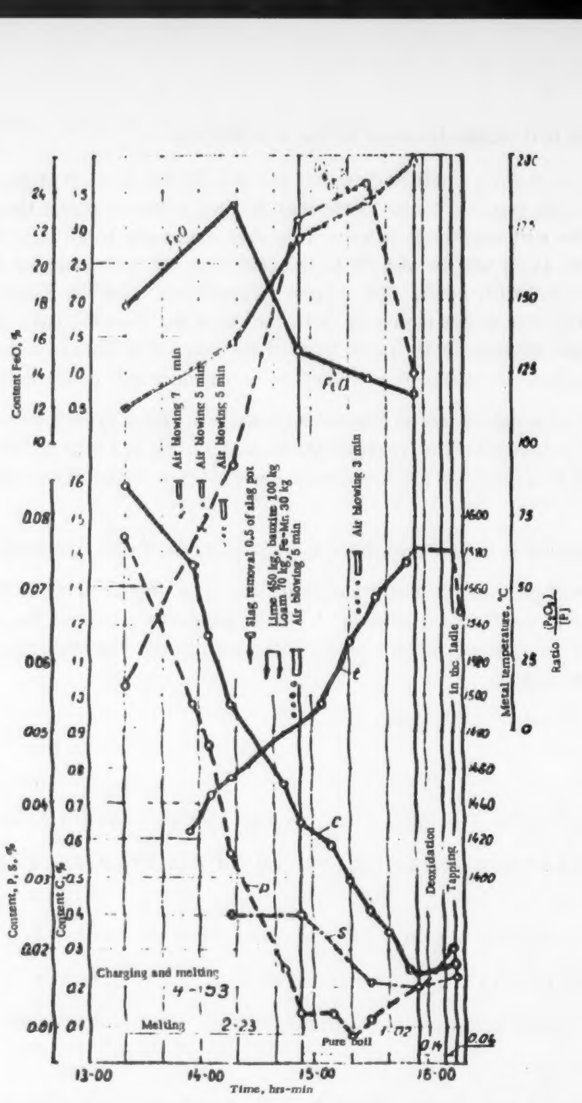


Fig. 1. Change in the composition of slag and metal in the course of the heat in the 30-ton open-hearth furnace (slag formation before melting; compressed air blown into the metal).

The blowing of the bath with air is most effective in the ore and the scrap-and-ore open-hearth processes in which there is a high content of carbon and conditions for a prolonged blowing-through of the bath. However, even in the scrap process it is possible to reduce the duration of heats and the consumption of fuel considerably. This is confirmed by the tests carried out at the "Krasnyi Oktiabr' "Works and at the KMK, and by long-established practice at the "Serp i Molot" Works.

Experimental heats carried out in the 30-ton open-hearth furnace at the KMK* showed that in the scrap process, compressed air can be successfully introduced into the bath not only during the refining period but also during the melting period, thus speeding up the melting of the charge on account of "scrap cutting" (as in oxygen blowing). By blowing air for the total period of 30 minutes the duration of the heat is reduced by approximately 30-40 minutes.

In one of the experimental heats (Fig. 1), air blowing through a lined tube (700 standard cu m/hr input, 4.5 atm pressure) was started after 1 hour 20 minutes of melting. The blowing of the melted portion of the metal

* Carried out in 1954 by M. Ia. Medzhibozhskii with I. A. Sokolov and M. M. Bazhenov.

with air caused a considerable rise in the temperature and a marked speeding-up of the scrap melting.

The rate of carbon removal during the blowing constituted about 0.03% C/min (1.8% C in one hour). The blowing-through of the bath allowed a complete dephosphorization of the metal and the formation of slag at the end of the melting period, thus eliminating these operations from the refining period. It is seen from Fig. 1 that the blowing also ensured a marked heating-up of the metal even at the time of slag formation during the melting period. It follows that the increased rate of heat transfer from the flame to the metal and a high heating effect of the combustion reaction of carbon interacting during the blowing (mainly with the hot oxygen of the furnace atmosphere) more than compensated for the heat lost in the melting of the scrap and slag-forming additions.

At the "Serp i Molot" Works the blowing through of the bath with compressed air in the 70-ton furnaces operating on the scrap process, was introduced in 1951.* Iron tubes of $^3/_4$ in diameter introduced into the metal at an angle of 30-45° to a depth of 100-200 mm under the slag, are employed for blowing. This method of intensification of the steelmaking process is included in the technological instructions which allow the introduction into the bath either of compressed air or oxygen (through an iron tube or a water-cooled nozzle) during the melting period (for "cutting and melting of the charge") and during the boil period when carbon steels as well as alloy steels are made.

TABLE 1

Comparison of Various Methods of Oxygen and Compressed Air Application in 70-ton Open-Hearth Furnaces of the "Serp i Molot" Works (mean data over 4 years)

Method	Number of heats	Duration, hrs-min				Specific consump. conven. fuel kg/t	Hourly output t/hr	Comparison with ordinary heats in 1950, %	
		charging	melting	refining	total heat (without fettling)			change in specific consumption of fuel	increase in hourly output
Carbon steel									
"F"	7830	2—03	2—31	1—42	6—16	197.3	10.70	Increase 0.70	14.55
"K"	1161	2—06	2—27	1—39	6—12	182.0	10.77	Reduction 8.30	15.62
"SM"	1671	2—01	2—27	1—39	6—07	186.5	10.92	Reduction 6.00	17.23
Alloy steel									
"F"	2275	2—00	2—23	2—14	6—37	204.2	10.14	Increase 2.92	9.08
"K"	200	2—02	2—19	2—12	6—33	186.1	10.21	Reduction 6.20	9.67
"SM"	264	1—57	2—18	2—07	6—22	192.0	10.49	Reduction 3.21	12 64

Note. "F" – oxygen introduced into the flame only (during the charging and melting periods); "K" – oxygen introduced into the flame (during the charging and melting periods) and into the bath (at the end of the melting and during the refining period); "SM" – oxygen introduced into the flame (during the charging and melting periods) and compressed air introduced into the bath (at the end of the melting and during the refining period).

The results from a large number of heats, in which various methods were employed, showed that the blowing of the bath with compressed air has approximately the same effect as the blowing with oxygen. Taking into account the substantially lower cost of compressed air than oxygen, the "Serp i Molot" Works prefers the blowing through of the bath with compressed air, oxygen being introduced into the flame only during the charging period and during the first half of the melting period.

The mean results given in Table 1 show that the blowing of the bath with air is quite effective and the results are not inferior to those on oxygen blowing.

In most of the cases the air blowing of the bath is applied at the end of the furnace campaign and therefore the results which can be obtained will be much higher than the results quoted in the table.

* Engineers Ia. L. Rozenblit, G. V. Sviridov, L. A. Smirnov and A. D. Zaitseva took part in the development of the technology and the adoption of compressed air blowing.

The effect of blowing the bath with air during the heat and its separate periods is better represented by Fig. 2. The curves, obtained from the data of 200 heats carried out at a relatively similar state of the furnace, show that with the increase of the time of air blowing up to 30-40 minutes the duration of the heat in the 70-ton furnace decreases by approximately 40 minutes compared with the heats without air blowing (on account of the reduction of the melting and refining periods).

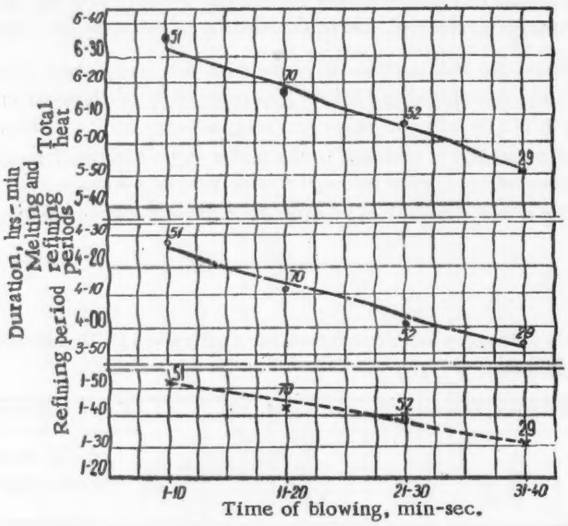


Fig. 2. The effect of the time of compressed air blowing on the duration of the heat (70-ton). The figure at each point indicates the number of heats under test.

Evaluation of the results from a large number of heats disclosed that during the blowing of compressed air the rate of decarbonization is approximately the same as during the blowing of oxygen (Table 2). Experimental results show that by increasing the rate of compressed air (cu m/ton • hr) blown into the bath it is possible to increase the rate of carbon removal markedly.

From the data in Table 2 the utilization coefficient of oxygen blown into the bath for carbon oxidation reaction is

$$K = \frac{O_{CO}}{O_B},$$

where O_{CO} – consumption of oxygen for carbon oxidation in the bath;

O_B – amount of oxygen blown into the bath.

When oxygen is blown, $K \approx 1$ and only in some heats attains 1.5. When air is blown, $K \approx 7$ and this figure indicates an enormous taking-up of oxygen from the furnace atmosphere by the charge as a result of a direct contact of the liquid metal with the atmosphere in the zone of blowing and a vigorous mixing of the metal and the slag in this zone.

Long experience at the "Serp i Molot" Works and at other works showed that the blowing of the bath with air does not impair the quality of the steel and this treatment does not result in an increased nitrogen content in the steel.

The blowing of the bath with air caused no marked decrease in the durability of the furnace. Undoubtedly, the splashing of metal and slag and the increase in the amount of dust in flue gases reduce the life of the furnace lining to a certain extent. However, when the method of blowing is properly worked out this reduction is small and it is compensated by the saving resulting from the reduction in the time of a heat and in the consumption of

TABLE 2

Mean Rates of Carbon Removal During the Blowing of the Bath (70 ton) with one tube (¾ in diameter)

Method of blowing	Mean pressure in the mains, atm	Input, standard cu m/hr	Mean rate of carbon removal, % C/hr	
			during the time between the samplings before and after the blowing	during the time of blowing only*
With oxygen	9	800	0.87	1.27
With compressed air	5	500	0.84	1.12

*Calculated from the formula $v_{ac} = \frac{60 \cdot \Delta C - v_C \cdot \tau_i}{\tau_b}$

where ΔC = amount of carbon removed during the time between the samples before and after the blowing, %;

v_C = rate of carbon removal during ordinary pure boil (without blowing and without the addition of ore), % C/hr;

τ_i = time when blowing is interrupted in the course of the period between the samples mentioned above, min.

τ_b = time of blowing, min.

fuel. Compared with oxygen blowing during which a high temperature (about 2500°C) in the zone where oxygen is introduced causes an intensive vaporization of iron, the blowing of the bath with compressed air is accompanied by a considerably smaller dust evolution and a smaller degree of erosion of the furnace lining.

The adoption of a refractory cover of the tubes prevents their deformation and hence a strict control of the depth and the inclination of the immersion of the tubes into the bath is made possible.

The above measure, while resulting in an extended life of the tubes, assists also in extending the life of the furnace. Further improvements of the method of blowing the bath with air (control of fuel consumption, control of lining temperature, introduction of special nozzles limiting the amount of splashes and dust, etc.) will allow a considerable increase in the durability of the furnace.

ROLLED STEEL AND TUBE PRODUCTION

THE ROLLING OF SPRING STRIP WITH PARABOLIC EDGES

Head of the Rolling Plant M. I. Lobarev
Senior Roll Designer of the Rolling Plant V. S. Berkovskii
"Dneprospetsstal" Works

Spring strip 6 × 45 mm with parabolic edges (Fig. 1) is used for the springs in "Volga," "Pobeda" and GAZ-69 automobiles.

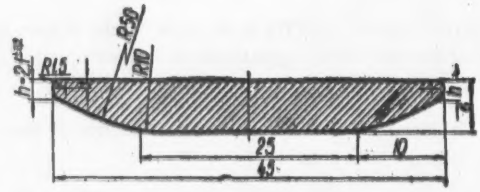


Fig. 1. Spring strip with parabolic edges (GOST* 7419-55).

The springs assembled from the strips of this cross section are very strong and comparatively light (their weight is reduced by 8-10% compared with the springs used previously).

Our Works began the production of spring strip in 1947. Until now, however, not all the problems of the method of rolling of this section have been fully solved.

A specific problem in the rolling of the spring strip with parabolic edges is the difficulty in producing a symmetric profile with equal thicknesses of the edges h. As is seen from Fig. 2, the shape of the contour is such that on a displacement of the strip in the pass by an amount f, the difference in the thickness of the left and the right edges Δh is of the same value ($\Delta h = f$). At the same time, under the conditions for rolling the strip on a mill, the forces tending to displace the strip horizontally and the amount of the displacement are considerable. Hence, the main problem in the roll design for spring strip is to attain the stability of strip in the pass, the stability being affected, in the main, by two factors: the shape of the profile and the distribution of the reduction in the lateral cross section of the strip.

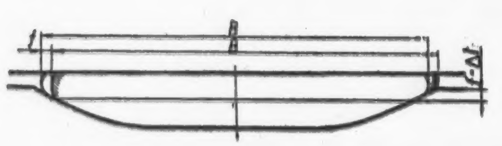


Fig. 2. Formation of nonsymmetrical edges on the displacement of the strip in the pass.

The shape of the profile in the case under consideration is not conducive in any way to the stability of the strip in the pass, but, being given, it cannot be modified. Hence, we shall consider only the distribution of cross sectional reductions.

Two versions of the distribution of reductions are employed in the existing pass designs for the rolling of spring strip with parabolic edges (Fig. 3): a smaller reduction at the edges than in the central part of the strip (Curve a) and vice versa, a smaller reduction in the central part than at the edges (Curve b).

The first version was used in the roll design for the following reasons the thickness of the edge h is nearly filled in the vertical pass and therefore, on a horizontal displacement in the finishing pass, the strip, having a minimum reduction at the edges, receives only a slight increase in the reduction and hence a slight increase in the spread. Therefore, on a horizontal displacement, the thickness of the edge will not be significantly changed.

* All-Union State Standard.

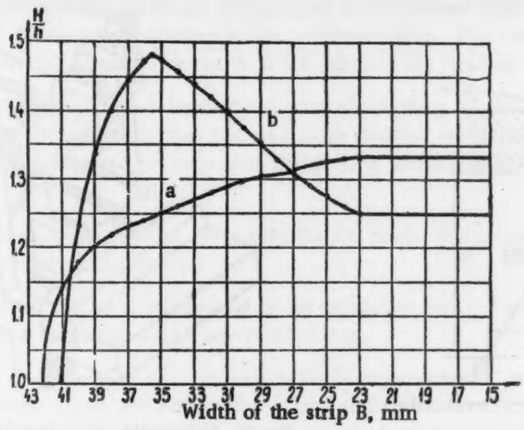
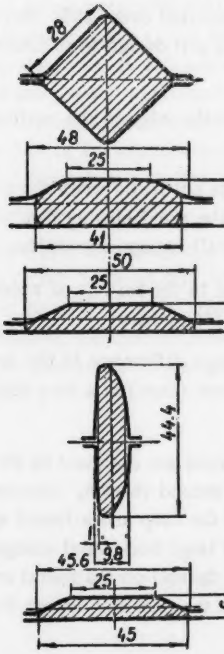


Fig. 3. Distribution of reduction on the cross section of the strip.



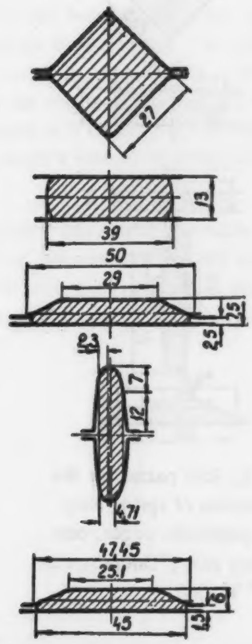


Fig. 4. Roll passes for the production of spring strip with parabolic edges; minimum reduction at the edges. (The Stalino Metallurgical Works).

Fig. 5. Roll passes for the production of spring strip with parabolic edges; maximum reduction at the edges ("Dneprospetsstal" Works).

In such a roll design, however, the spread of the metal is restricted and the horizontal component of the compressive force of the roll on the metal is even more reduced. Hence, there is no opposition to the forces tending to displace the strip horizontally. The strip is displaced in the pass and from time to time unsymmetrical edges or even fins are produced.

The roll design for rolling spring strip at the Stalino Metallurgical Works* is based on the above method (Fig. 4). Until the present, there was a considerable amount of defective product at this Works due to the unsymmetric edges of the section.

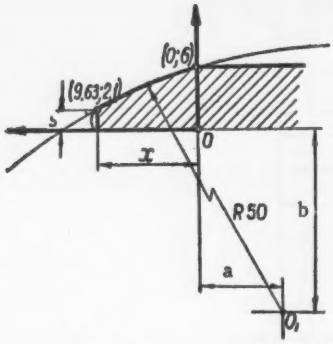


Fig. 6. Diagram for the analytical evaluation of the finishing pass.

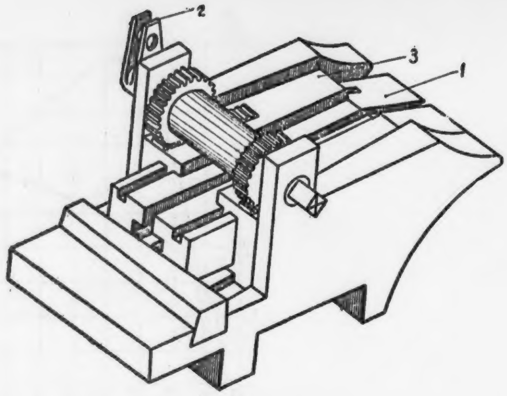


Fig. 8 Automatic guide box (the passes are removed).

Originally, when the production of spring strip was introduced at the "Dneprospetsstal" Works, a similar roll design was tested. The defective material due to unsymmetric edges constituted over 25%. Several substantial defects of such a roll design were found during testing:

1) a small size of the edge in the vertical and pre-finishing passes;

2) the edge pass is not filled when the smallest nonsymmetry occurs in the pre-finishing pass and hence the adjustment of the mill becomes unstable;

3) a complication in the rolling on account of the increased number of shaping passes;

4) a relatively large difference in the draft at the edges of the strip (crescent shape) at a very slight skewing of the rolls.

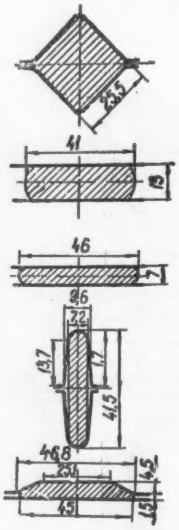


Fig. 7. Roll passes for the production of spring strip with parabolic edges; one shaping pass ("Dneprospetsstal " Works).

Quite different results are obtained in the rolls designed according to the second version. Increased reductions at the edges of the strip and a forced spread cause the appearance of large horizontal components of the pressure forces of the roll on the metal and these forces center the strip in the pass and oppose its horizontal displacement.

The passes of the 325 mill at the "Dneprospetsstal" Works, designed on the above principle (Fig. 5) are free from the defects of the pass design described earlier; faulty production due to defective edges is prevented and the output of the mill is considerably increased. The rolling of square billets in plane rolls allowed the use of transfers and established conditions of deformation in the pre-vertical pass as described in the second version (Fig. 3), Curve b) and therefore it was possible to dispense with a complex guide box in this pass.

The finishing pass with permitted tolerances, is designed by means of the equation derived for the parabolic part of the spring of 50 mm radius (Fig. 6):

$$(x + 13.858)^2 + (y + 42.043)^2 = 50^2.$$

Given one of the quantities — $\underline{x}$ or $\underline{y}$, — the other can be determined.

The shape of the curvature of the top of the vertical pass is determined from the condition of the curvature symmetry of the edges of the finished strip relative to the horizontal axis. The choice of maximum reduction in the finishing pass is determined by a smooth curvature of the edges of the finished strip.

When technical conditions do not predetermine the form of rounding off the edges of the section, the roll passes can be considerably simplified by applying the maximum limiting reduction at the edges (Fig. 7). Large reductions made it possible to dispense completely with the shaping passes thus making the adjustment of the mill simple and stable.

The introduction of the above roll design made possible the production of spring strip with parabolic edges of high accuracy within the permitted tolerances.

The curvature of the vertical pass is determined by the condition that it should be completely filled up, and this is assisted by curvature formation in the pre-vertical pass.

The tests of the above roll design on the 325 mill of the "Dneprospetsstal" Works showed a very good stability of the strip in the pass. With the above roll design, the output of the mill on rolling spring strip with parabolic edges is approximately the same as on rolling strips of ordinary cross section. From September to November, 1957, 568 tons of springs was rolled by this method. Faulty product on account of edge defects amounted to 0.2 ton and total defective product amounted to 2.6%.

The introduction of the automatic guide box Fig. 8, designed at the Stalino Metallurgical Works, made the rolling of spring strip with parabolic edges considerably easier. The guide box functions as follows. In the normal position the passes (1) of the box are open. The strip is thus easily put between the rolls. After the strip is gripped by the rolls, an electromagnet, mounted above the stand, actuates the lever (2). The passes are moved forward, and are pressed together by means of the wedge (3) so that they hold the strip firmly. When the strip leaves the rolls,the electromagnet is switched off and thepasses return to the original position. The impulse for the switching-in of the electromagnet is provided by the lifting of the upper roll on gripping the strip, and it is transmitted through a textolite bearing, sliding over the roller, and through a system of levers to the switch of the electromagnet.

It should also be mentioned that the design of the profile (of the spring) itself with parabolic edges as specified by GOST 7419-55 (Fig. 1) contains several defects. In particular, the curvature of the edge of 1.5 mm radius cannot be strictly maintained on hot rolling because the edge itself is formed in the free gap between the rolls. In addition, tolerances allowed by GOST 7419-55 for the dimensions of the edge h of the strip are not related to the tolerances for the width and the thickness of the strip.

PRODUCTION OF NEW SECTIONS FOR MINING CONSTRUCTIONS

M. L. Mirenskii

Engineer Roll-Designer of the Kuznetsk Metallurgical Combine

Special new sections have been designed for the movable parts (Fig. 1, a) and for the body (Fig. 1,b) of mine props. The first section is used as a wedge. Two pieces of this section are welded together along the flanges (legs) so that the two plane surfaces (65 mm wide) are not parallel but slightly tapering. The sections for the movable parts of the props are made of 30 KhGS steel, and for the body of 35 steel.

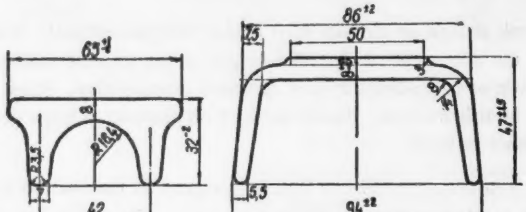


Fig. 1. Special sections for mine props.

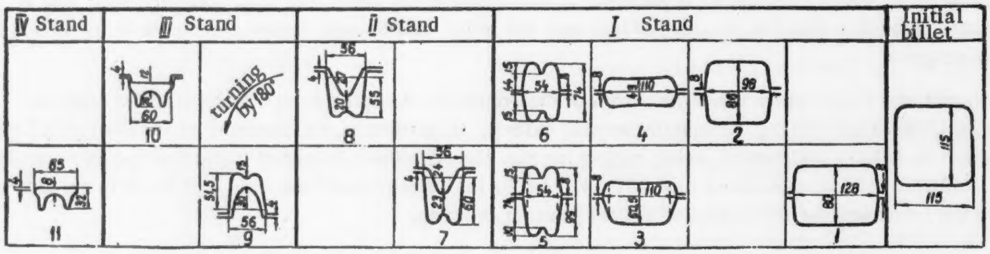


Fig. 2. Successive roll passes for the production of section for mine props: the figures 1, 2, 3, ... denote the number of pass.

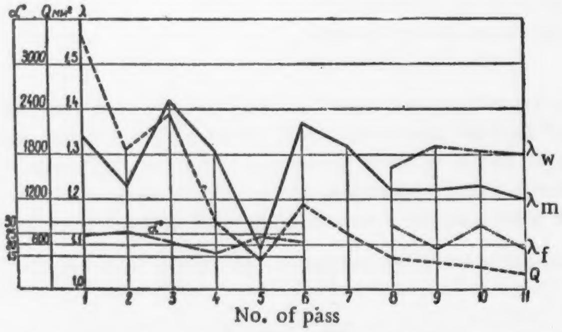


Fig. 3. Analysis of roll passes for the production of steel section for mine props: λ_w) reduction of the web; λ_m) mean reduction in the pass; λ_f) reduction of the flange; Q) reducing area; α^0) angle of bite.

The sections are rolled in a section mill consisting of four stands arranged in one line; the first three are three-high stands and the fourth – a two-high one. The piece is transferred from one stand to another in the front part of the mill by pull-over transfers and to the higher passes – by a roof lift.

The section for the movable parts of the props is rolled from square billets of 115 mm side in 11 passes (Fig. 2). Analysis of the roll design is given in Fig. 3.

To obtain projections extending outside the legs of the section, the legs being relatively thin and long, in the last four passes (8-11) an extensive nonuniform deformation takes place between the web and the flanges (legs), the web undergoing a bigger deformation than the flanges. The nonuniformity of deformation in the 8th and 9th passes results in a rapid formation of the flanges on account of the direct lateral reduction of the transfer of metal from the covered up part of the pass – i.e., from the web, where a substantial deformation of metal takes place, into the open part – i.e., into the flanges. The rapid formation of the flanges in the 9th pass is assisted by sharp cutting ledges in the 7th and 8th passes, and a favorable ratio of metal mass in the web and the flanges in each pass (the surface area of the flanges is much larger than that of the web). In the 10th and 11th passes the flanges are not worked up laterally and are only slightly reduced longitudinally, but the web is substantially expanded on account of an intensive deformation: by 10 mm in the 10th pass and by 6 mm in the 11th pass. This process is made easier by the available "spare" metal on the sides and the top of pass 9.

The height of the flanges in the 9th pass and the length of the legs in the finishing (11th) pass are so designed that the passes must be filled up with metal and thus an equal height of both legs – a very important characteristic of the section – is ensured.

The manner in which the lines of the reducing areas Q (the difference between the area of a given and the preceding pass) and of the mean spread λ_m (Fig. 3) in the first four passes change, depends on the conditions under which the shape of the 6th pass is obtained from the 115 mm square billet. The small values of Q and m in the 5th pass are the result of the beginning of the slitting of the section; starting with the 6th pass the values of Q and γ_m gradually decrease.

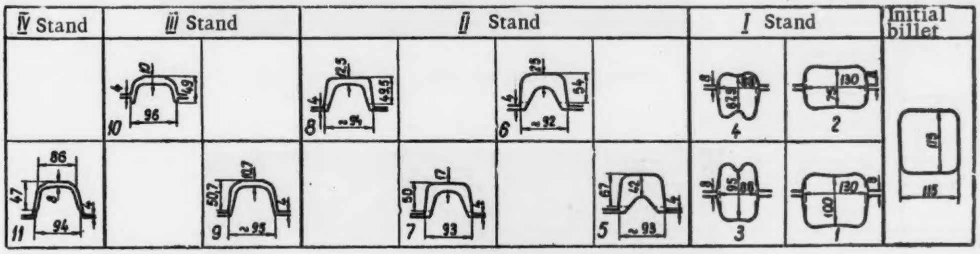


Fig. 4. Roll passes for the production of steel section for the body of the mine props: the figures 1, 2, 3, etc. denote the number of the pass.

The positioning of passes 7, 8, 10 and 11 (Fig. 2) in the rolls was necessary to ease the operation of the guides. In the 7th and 8th passes there are only bottom pass guides which are easier to install and are more reliable than the top ones under the conditions at our works. In passes 10 and 11 the main guides are the bottom ones but the top ones are also applied and their action is limited to directing the piece after the delivery from the pass. Pass 9 had to be positioned in accordance with pass 10 which is on the same stand. Pass 9 has bottom and top pass guides.

The passes for the section for the body of the mine props are designed similarly to the roll passes for rolling channel beam (Fig. 4). The section is rolled from 115 mm square billet in 11 passes, passes 1-2 and 3-4 being conjugated. Pass 10 is intended mainly for finishing work – bringing both flanges to the same length.

A small angle of bite α was selected for pass 1 (Fig. 5), because at a large angle of bite the piece is not properly gripped (slips occur) owing to the surface of the billet being covered with furnace scale. The increase

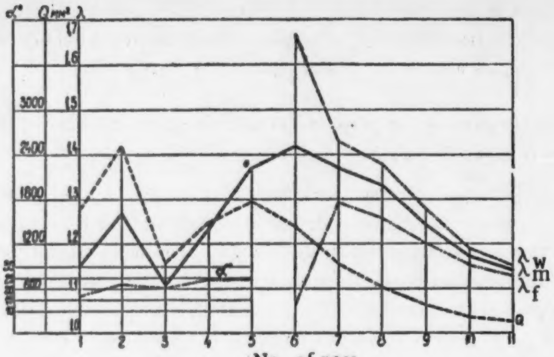


Fig. 5. Analysis of roll passes for the production of steel section for the body of the mine props: λ_w) reduction in the web; λ_m) mean reduction in the pass; λ_f) reduction in the flange; Q) reducing area; α^0) angle of bite.

of the angle of bite and hence the increase in the reduction in pass 4 as compared with pass 3 is aimed at a filling-up of pass 4 with metal. The deformation in passes 4 and 5 is limited by a large angle of bite (24°).

The lines for mean reduction λ_m and reducing areas Q for the remaining passes show a gradual smooth fall. Beginning from pass 7 the lines for web reduction λ_w and flange reduction λ_f converge, so that in pass 11 they are nearly equal and this factor contributes to a steady delivery of uniform piece from the finishing pass.

In other respects the rolling of steel section for the body of mine props is exactly the same as that of the ordinary channel beam.

MECHANIZATION OF LABOR-CONSUMING PROCESSES IN THE SHEET STEEL ROLLING MILL

A. V. Serebrenikov

The Verkh-Isetsk Metallurgical Works

A special technological feature of rolling transformer sheet steel is the high temperature of the metal (1170-1260°C for sheet billets and 1000-1040°C for packs) and high output of the stands reaching 2.5 tons per hour in a busy time.

It was difficult to cope with the work of these sections without additional mechanization.

The sheet billets were transferred manually from the furnace to the mill by junior furnace attendants. When it is considered that the distance between the furnace and the stand is 10 m and that in a shift about 900-1000 packs are rolled, the junior furnace assistants have to cover up to 20 km in a shift.

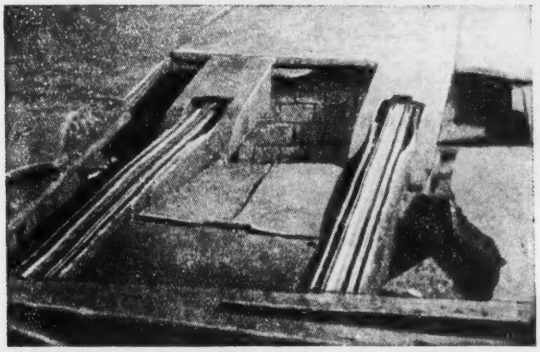


Fig. 1. Front end of the conveyor (receiving part).

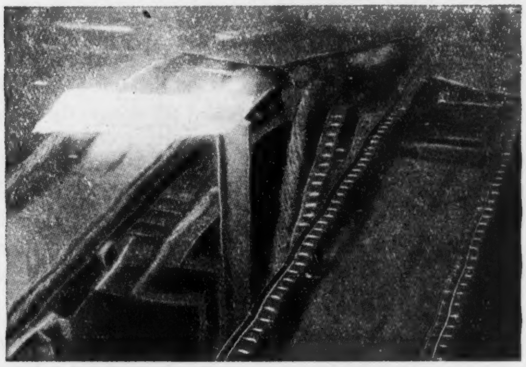


Fig. 2. Back end of the conveyor (elevation before the stand).

To relieve the junior assistants from heavy work, conveyors (Fig. 1) were installed between the billet chambers of furnaces Nos. 4 and 5, the main line of the conveyors, 14 m long, going directly to the stands.

The delivery of the sheet billets on the other side of the furnace is carried out on a narrow conveyor which passes under the front chambers of the furnace and serves for transferring sheet billets on to the main line of the conveyor.

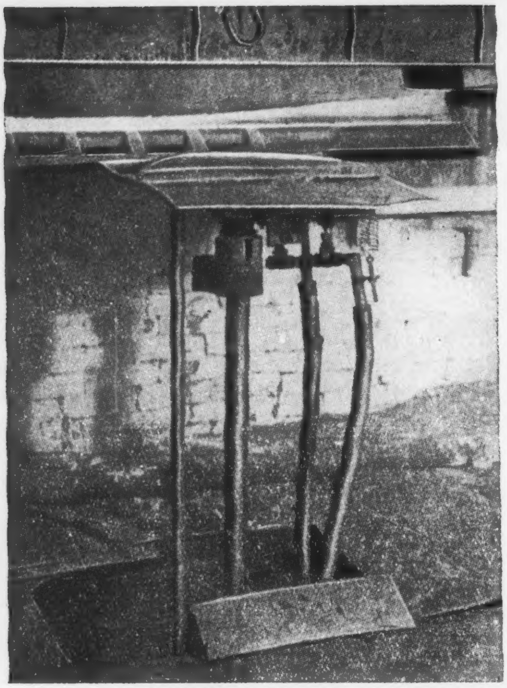


Fig. 3. Lifting table.

The receiving section of the conveyor is located under the floor, the sheet billets falling onto it through a special opening. The other end of the conveyor approaches the stands and is elevated by 1320 mm. The sheet billet moving at 1.93 m/sec is lifted on the conveyor (Fig. 2) and then slides on rollers to the bogies.

The sheet rolling plants have semi-automatic doublers, which were designed at the Lysvenskii Works, placed on the side of or behind the stands.

With such a layout of the stands the doubler operator begins the breakdown of the next pair of packs immediately after the last pass, the operation thus being speeded up and a regular flow of material ensured.

To facilitate the transfer of doubled packs to the furnace, stand No. 5 is also equipped with a conveyor. The belt to the conveyor from the doubler passes under the shaft and leads directly to the furnace.

As the speed of the conveyor is fairly high (1.18 m/sec) the packs delivered to the furnace do not cool down and are placed hot into the chambers; hence the heating process is shortened and the metal quality improved.

The packs are charged into the furnace by means of pneumatic tables.

When a 20-30 kg pack is thrown onto the table a pedal is pressed down and the table is lifted by compressed air (Fig. 3).

In order to facilitate the work of rolling mill operators, similar lifting tables are set up in front of the stand. The packs, weighing 30-40 kg, when placed by a junior furnace attendant on the table are lifted 860 mm and the mill operator transfers them via an intermediate table onto the stand for rolling.

The pressure adjustment equipment with a hand wheel has been replaced by an electrically operated one.

A 6 kw electric motor, situated near the top of the main screw, imparts the motion to the pressure screw through a reduction worm gear.

In addition, the motion is imparted through a connecting shaft to a second reduction worm gear mounted at the top of the second pressure screw.

The speed of lifting and lowering the screws is 3.92 mm/sec. As a whole system is adequately rigid there is no free play, and an equal reduction at both screws and a good quality of the product are ensured.

The control panel for the pressure adjustment equipment is at the back of the stand.

The increasing productivity, kg/hr, of stand No. 5 is 0.5 × 750 × 1500 mm transformer sheet steel rolling, prior and after the mechanization, is illustrated in the table.

Output Increase in 1955-57

Prior to mechanization 1955	After mechanization 1956	After mechanization 1957
1829-2175	1983-2272	2063-2296

As a result of the mechanization, much less labor is expended on all operations and occupational diseases are declining. More attention is constantly paid to the heating of metal and the maintenance of the rolling mill and hence the quality of the sheets with respect to their surface and decarbonization, improved.

EXPERIENCE IN THE OPERATION OF COLD-ROLLING MILLS

G. A. Grekhov

Mechanic of Plant No. 6 of the Pervouralsk New-Tube Works

The manufacture of seamless tubes by the cold rolling method has taken a permanent place in the drawing plants of the tube works in our country.

This method had a decisive effect on the increase in production of high-quality thin-walled carbon tubes and in particular stainless, fire-resistant, bearing tubes and tubes for high pressure work.

The basis of the technology of the manufacture of seamless, thin-walled, small diameter (up to 100 mm) tubes from alloy and special steels in newly projected plants and plants under construction is provided by cold rolling, recognized as the most advanced and effective method for production of these tubes.

The home machine industry has mastered the production of first-class tube rolling mills including cold rolling mills KhPT-75, KhPT-55 and KhPT-32, designed and manufactured at the Urals Heavy Machinery Plant (UZTM).

The UZTM mills for cold rolling have several advantageous features distinguishing them from other mills. The main differences are: a longer pass of the working stand and a larger turning angle of the rolls; a larger permissible deformation of the piece because the bearings of the working rolls are substantially strengthened; a greater length of initial piece; a greater speed of the plyer. The above factors contributed substantially to the increase in output of cold-draw tube mills.

The cold-draw mills KhPT-75, KhPT-55 and KhPT-32 were introduced at the New-tube Works. The personnel of the works together with designers from the UZTM and scientists from the Urals Polytechnical Institute carried out an extensive investigation on increasing the service life of the separate parts and units of the mill and as a result of the investigations the design of the various units and parts was modified, allowing a reduction in stoppages of the mills, an increase in output and a reduction in expenditure on current repairs.

Below are given the causes of stoppages and the steps which have been taken for their elimination in separate units of the mill.

Working stand. Most stoppages occur on roll changing because the bearings get worn out or break down. The life of the bearings in theUZTM mills is three times longer than in mills of other design. The life of

roll bearings increased substantially when safety devices protecting the bearings from overloading were introduced.

To reduce stoppages on roll changing it is necessary to have a completely assembled spare working stand. On KhPT-75 and KhPT-32 mills there were occasions when the axles of the working stand rollers broke down. To eliminate these stoppages the bearings on KhPT-32 mills were set nearer to the rollers and the diameter of the journal for rollers was increased (Fig. 1). When on KhPT-75 mills the radius of the fillet in the transition section from one diameter to another was increased by 5 mm, breakdowns of the axles ceased. The operational experience at the New-tube Works showed that it is expedient to replace the sliding blocks on the rear axles of the stand on KhPT-32 mills with rollers. In this case the rails on which the working stand moves are made of hardened steel, ShKh15. When the rails get worn they are reconditioned by plating with a hard alloy and polishing.

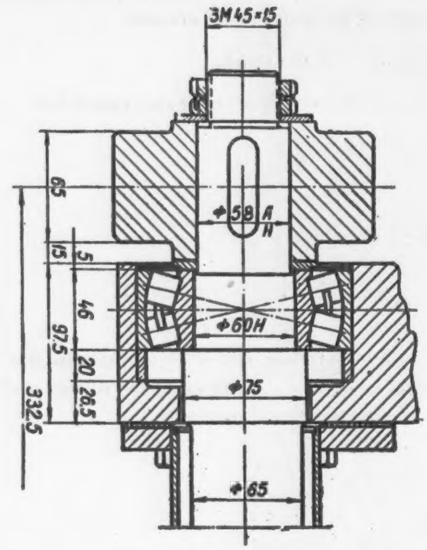


Fig. 1. New positioning of bearings and rollers in the KhPT-32 mill.

Driving gear mechanism of the working stand. Here, the stoppages are caused by fractures of the spindles, crankpin and shafts of the crankgear. To increase their life, the spindles at the New-tube Works are made of forged steel instead of cast. The crankpins of the crankgear are provided with spherical bearings instead of conical roller bearings, the life of the spindle being thus considerably increased. The durability of the shafts and crankpins of the crankgear was very much enhanced by the use of alloy steel for their manufacture and by smooth transitions from one diameter to another.

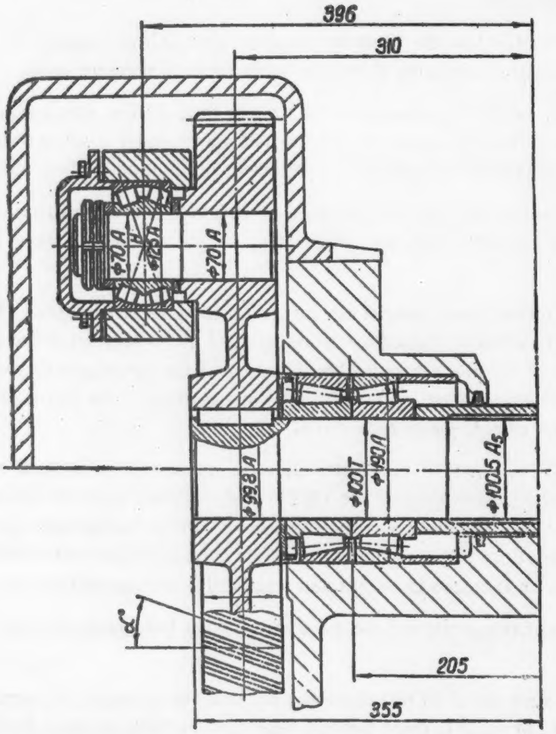


Fig. 2. Crankgear unit of the KhPT-32 mill.

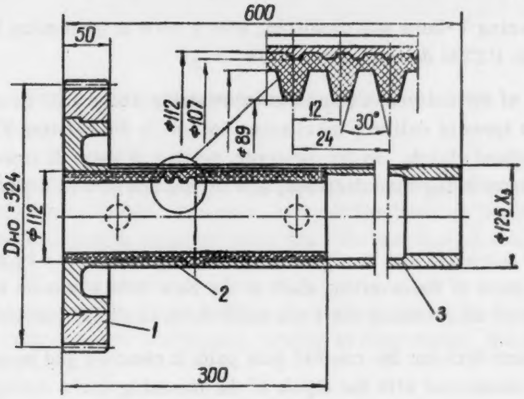


Fig. 3. Bimetallic locknut:
1) collar (steel 40 Kh); 2) bronze lining; 3) casing.

The helical tooth gear is fixed in the direction along the axis; the driving gear unit is made self-adjustable with respect to the crankgear unit. The helical gear couple compensates any inaccuracies in the assembly of both units (Fig. 2).

In addition, the double movements of the working stand in KhPT-55 mill have been limited to 75 per minute. Tests showed that, with the increase in the speed of the working stand, the stresses in the parts of the working stand drive increase considerably. It is not expedient to operate KhPT-55 mills at a speed of the working stand of more than 75 double movements per minute because the stoppages due to mechanical breakdowns increase markedly and hence the over-all efficiency of the mill is lowered. On operation at 75 double movements, the loss in output is compensated nearly ten-fold by an increased delivery and a reduction in stoppages due to mechanical breakdowns.

Main reduction gear. The pinions of the main reduction gears in KhPT-55 and KhPT-32 mills are frequently cut out of action because of a wearing out or fracture of the teeth. According to the UZTM recommendations, the gears of the main reduction gear must be made of a special alloy steel. This, however, did not result in a radical improvement in the operation of this unit. The main reduction gear of the KhPT-32 and KhPT-55 mills still remains a bottleneck because of the lack of a bench for machining of gears and facilities for their heat treatment. The main reduction gear in the KhPT-75 mills works for a long time without stoppages.

The delivery equipment of the KhPT-75 mill has every chance to operate with minimum stoppages. It is only necessary to use through-hardened and accurately ground teeth and sockets in the lever system.

The main defect of the KhPT-32 mill is an unfortunate design of the delivery equipment which requires very accurate adjustments. The adjustments are time consuming and the equipment frequently stands idle.

A weak point is also the delivery fork which is of a low durability. The adjustment of the delivery equipment for operation with a lock spring – similar to the KhPT-55 mill – is not possible because the thin-walled tube material gets damaged. The following measures were carried out in order to improve the operation of the delivery mechanism of the KhPT-55 and KhPT-32 mills:

1) locknuts are made of two metals: the casing is made of steel, and bronze is poured inside;

2) the length of the threaded part of the locknut is increased to 300 mm; by this means the service life of the locknut was increased by a factor of 1.5;

3) the collar of the locknut is made of steel instead of bronze (Fig. 3);

4) the nonvariable reduction gear is replaced by a gear box with changeable gears, the manufacture of parts being thus facilitated and stoppages reduced;

5) the mechanism for switching from the working to a higher speed is modified: the front toothed clutch is replaced with the friction disc clutch of a design similar to the friction clutch of a lathe, and the switch

cylinder is taken outside the housing, its operation and maintenance being simplified;

6) the equipment for tightening V-belts was modified, with a view to increasing the tension of the belts as the durability of the belts of the UZTM design was very low.

The constructional changes of the delivery equipment enumerated above still do not eliminate its principal defects. The UZTM designed two types of delivery mechanism for use in the existing KhPT-32 mills: with hydraulic drive and with ratchet wheel clutch. So far, however, neither of these devices has been tested at the New-tube Works because they are now being manufactured, and we are not now in a position to report on their serviceability.

Reversing mechanism. The stoppages due to reversing mechanism are caused by the fracture of the conical gears of the reversing shafts. The gears of the reversing shaft at the New-tube Works are straight-toothed, the gear ratio being 7 instead of 6. The housings of the reversing shaft are made detachable for convenient adjustment and assembly.

During the repairs, the contact between the conical gear pairs is checked and necessary adjustments are made. In this way, the stoppages connected with the repair of the reversing shafts during the mill operation were eliminated.

The bases of the working stand and of the delivery equipment are built without a bed plate. The base of the working stand is of a box-type and hence the filling of cavities under the base during repairs is not possible. Because of that style of design, the New-tube Works had to carry out major overhauls of these mills after three years of operation and to replace the foundations under the working stand as the base was supported only on laid strips and was sagging frequently so that the toothed coupling was put out of order.

A new, additional, pouring of cement under the bases is carried out through the openings cut with a gas flame in the base of the working stand and provided for in the design.

In future designs, it is advisable to incorporate a common bedplate for the base of the working stand and the delivery mechanism as is done in the KhPT-75 mill .

The modifications described above assist in the reduction of stoppages due to mechanical breakdowns, increase the output of cold-rolling mills and improve the quality of the finished product.

Technical potentialities, however, of the mills are not yet exhausted as the separate units and parts are continually being improved in the course of operation.

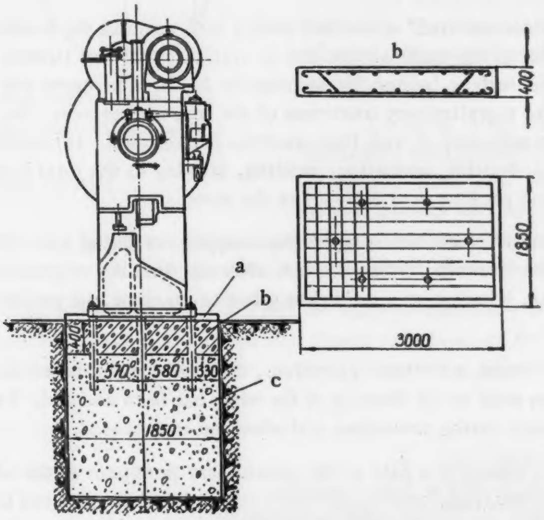
COMPOSITE FOUNDATIONS FOR HEAVY EQUIPMENT

P. I. Kovalev

Stalino Metallurgical Works

Composite reinforced concrete foundations are more and more frequently used for the erection of various pieces of equipment at metallurgical works. However, some difficulties are frequently experienced in connection with the transportation of the foundations prepared away from the erection site, and with the excavation of a foundation pit of specified size.

Composite foundations were made, in the rolling plant of our works, for sheet billet shears weighing 17.5 ton and exerting 160 ton cutting pressure (see figure). Owing to their design, the time required for the erection of the shears was substantially reduced.



Composite foundations for plate billet shears:
a) cement finish; b) reinforced concrete plate; c) concrete.

Work on the removal of the old foundations and the preparation of the foundation pit for the shears took 24 hours. During the next hour new concrete was laid as a base and a reinforced concrete plate, prepared previously, was placed on top of it. After 24 hours the shears were mounted on the plate. In this way, all work on the erection of the shears took two days.

One year's operation of the shears revealed no defects in the foundations.

The advantage of the method described lies in the fact that, owing to the reinforced concrete plate, the pressure on the foundations amounted to 0.32 kg/sq cm only, and when the plate was placed it floated, as it were, on top of the fresh concrete.

HARDWARE PRODUCTION

NEW TECHNIQUE OF MANUFACTURING CHROME-VANADIUM WIRE FOR SPRINGS

V. V. Fedorov, Works Director
Cand. of Tech. Sci., Ia. Kh. Sartan, Head of the Works Laboratory
"Proletarskii Trud" Works

For a long time, the "Proletarskii Trud" Works had nearly 50% waste in the production of wire from steel 50KhFA (GOST 3704-47) used for spring manufacture, due to cracks, seams and fissures on the surface of the wire and to the decarbonization of the surface beyond the permissible depth. The cause was the wrong production method which did not provide for a preliminary treatment of the wire rod surface. The method was in no way different from the method of manufacture of wire from medium carbon steel. It consisted of the following operations: pickling of wire rod, drawing, annealing, pickling, drawing to the final size, inspection and acceptance by the OTK, lubrication and packing, and delivery to the store.

At the Moscow "Serp i Molot" Works which is the main supplier of spring wire 50KhFA, the method of wire production until now included the trimming of the wire coil after the final drawing and heat treatment, the cutting of the wire into a uniform length, grinding on a centerless grinding machine and polishing. Such a procedure makes the product more costly.

At the "Proletarskii Trud" Works, a different procedure, which allows for the removal of surface defects at the very beginning of the process prior to the drawing of the wire, has been adopted. Furthermore, the method is less costly and there is less waste during production and when the wire is used.

In the new method special attention is paid to the preliminary treatment of the wire rod surface. First of all, the wire rod is subjected to annealing, then the scale is removed and the wire rod is pickled in sulfuric acid solution. After pickling, the initial drawing for the elimination of oval cross section of the wire and the grinding of the material on centerless grinding machines of a special design which allows treatment of the wire in coils takes place.

The new method of chrome-vanadium wire consists of the following operations: annealing of the wire rod, removal of the scale, pickling of the wire rod, drawing to eliminate the oval profile, grinding, annealing and pickling, drawing to final size, inspection and acceptance by the OTK, lubrication and packing, and delivery to storage.

The thinner the wire is required to be, the more times the annealing, pickling and drawing have to be repeated.

The annealing of the wire rod and intermediate material is carried out in ShO-130 type electric furnaces at 760°C, the exposure time being 2 hours for 800 kg charge and 4 hours for 1500 kg charge. For cooling, the material is placed in cooling pits.

These conditions of annealing ensure the ultimate tensile strength of material of not more than 75 kg/sq mm.

The removal of the scale from the surface of the wire rod is carried out by means of a roller scale breaker (Fig. 1), situated at the coiling drum. After it is rewound from the reel to the drum, the wire rod is passed between rollers which are arranged in such a way that the rod is bent and the scale is removed.

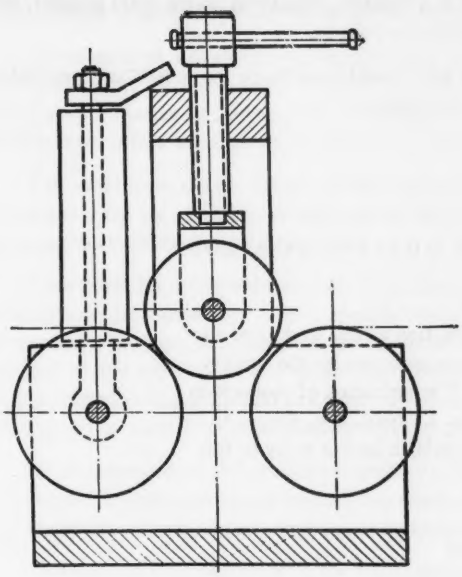


Fig. 1. Scale breaker.

The pickling of the material is carried out in sulfuric acid solution in the course of 10-15 minutes, the concentration of the acid being 18-8%. Rinsing and lime coating is done according to the generally accepted procedure.

The first drawing, for the elimination of oval shape, takes place on the single-stage mills 1/600 or 1/700 in one pass at 15-25% draft and 45-50 m/min speed.

The total draft in the finishing drawing to the final size is 30-40%. The pass design with such drafts ensures the ultimate tensile strength of not more than 103 kg/mm, which corresponds to a hardness of not more than 33 R_c, in conformity with GOST 3704-47.

The centerless grinding machine consists of three parts (Fig. 2): the charging cell where the wire coil is charged, the centerless grinding machine proper and the coiling cell.

Unwound in the charging cell, the wire is preliminarily straightened between three rollers mounted in the cell frame and then is finally accurately straightened between the rollers of the roll straightener. By means of guides, the wire is directed into the line of grinding and is then wound onto the drum of the coiling cell. On grinding on the centerless grinding machine a layer 0.2 mm thick is taken off the wire.

After the new method was introduced, the quality of the chrome-vanadium wire produced by the "Proletarskii Trud" Works markedly improved. Defects due to the decarbonization layer on the wire have been completely eliminated and the other defects, mentioned earlier, on the surface of the finished wire occur less frequently.

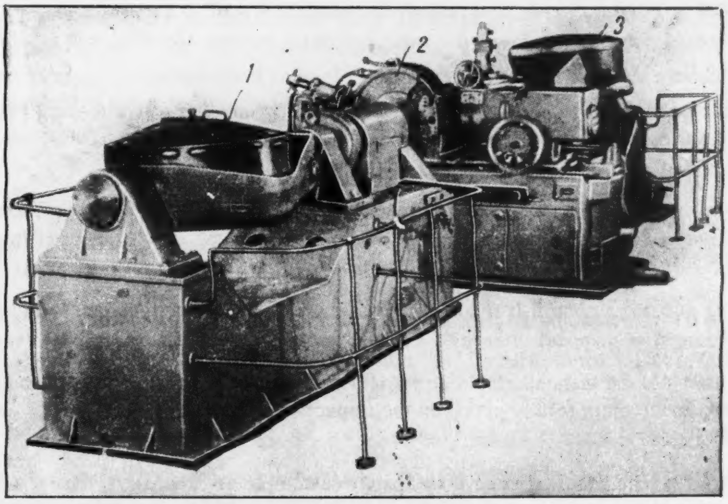


Fig. 2. Centerless grinding machine:
1) charging cell; 2) centerless grinding machine; 3) coiling cell.

In this connection, the question arises whether it would be expedient to produce silver steel by the new method with the adoption of grinding of initial material as a preparatory operation.

Up till now the silver steel, conforming with GOST 2588-44 and GOST 2589-44, is manufactured by all works in rods by the old method, in which grinding is included as a finishing operation on the final product, subjected to special straightening, and cutting into rods of a measured length.

Our experience in the manufacture of chrome-vanadium wire 50KhFA confirms the possibility, and indeed the desirability, of producing silver steel wire in coils by the new method.

ORGANIZATION OF PRODUCTION QUALITY CONTROL

The problem of the OTK staff reduction at the works and the extension of the responsibilities of plant employees for the quality of production, was raised in the article "Organization of production quality control" by N. P. Inozemtsev, Ia. I. Sokol, I. F. Rysev, D. A. Tarasenkov and S. I. Zamiatin. We publish here a reply to this article.

S. D. Golikov

Deputy Head of the OTK of the "Electrostal" Works

Since 1956, the management of our Works together with the department of work organization have been finding ways for reduction of the OTK staff by a general reduction in the number of ITR* and controllers as well as by the abolition of some inspection posts.

In the last two years the number of controllers on the steel pouring at the steelmaking plants was partly reduced. The number of the OTK employees was substantially reduced by the abolition of technological control in the forge and press plant, silver steel plant, in heat treatment processes, in ingot and final product storages and at the delivery from the 600 and 300 mills. In that period, the total OTK staff at our works was reduced by 20.1%; at present the OTK personnel constitutes 2.6% of the works industrial workers and ITPs, and if the OTK control laboratories are included it amounts to 4%.

As an experiment, the technological control on steelmaking and tapping in steelmaking plants was removed; the control was left only on the ingot cleaning operation and the transfer of ingot and cast billets to the rolling processes (one man per shift).

In the remaining steelmaking plants, where defective production is still relatively high, technological control was retained on charge preparation, steelmaking, tapping and on the cleaning and chipping of ingots handed over to the rolling operation.

In the steel rolling plants the control is retained, in the main, on inspection and acceptance of final products intended for the consumer and of material intended for further processing in the cold working department.

In the mills 600 and 300, the technological control is retained on the charging of ingots and billets into the heating furnaces and, in the plate rolling plant, on the inspection of the finish of the metal and for the prevention of confusion of steel grades.

In the plants where the technological control was partly or completely abolished, the responsibility for control was placed by order of the director on the plants personnel; accordingly, the rights and duties of the OTK workers were modified.

In the remaining sections supervised by the OTK, full or periodic inspection by the OTK personnel is carried out. The control findings are recorded in the work cards, furnace logbooks and other documents, and the

* Engineers.

records may be discussed (in the case of technological breaches) at the "Production Meeting" in the plant, during the "Production Quality Day" and on other occasions.

In our opinion, all violations of production technology should be investigated but the offenders should not be punished if the breach is not serious and does not result in faulty products, as the subsequent metal processing, through determination of the properties and right designation of steel, eliminate or at least minimize the defects resulting from minor breaches in technological processes.

The employees of the "Serp i Molot" Works have not considered another domain of the work of the control department – the prevention of technological breaches; this is done at the "Electrostal" Works and in this way some possible violations are eliminated.

Conditions for a full reduction of the technological control are not yet provided by the OTK. The control abolition must be carried out wisely, specific features of the production and established traditions being taken into account. For instance, the OTK of our works considers that the control of the charge in the steelmaking plant and of the initial material in the No. 1 rolling plant should be the responsibility of the plant while the plants persistently maintain that it should be left to the OTK. The steelmaking plants have no objections to the abolition of the control on steel pouring but the OTK considers that it most certainly should not yet be abolished.

As an experiment, the control on grading of the products is carried out directly in the thermal plant, in the heavy section rolling plants and in mill 600 where the controllers have been transferred to the staff of the plant and inspect the surface, shape, marking and preparation of the products for delivery to consumers through the OTK.

The grading and inspection of the small size and very important material, in particular from mill 300 and the plate rolling mill, are the responsibility of the control department. In addition, the department carries out the inspection of any type of finished products designated for the customer.

The OTK staff of the "Serp i Molot" works considers that the OTK sections should be enlarged. This, in the main, has been done at our works. The steelmaking section includes three steelmaking plants, the casting plant, the cleaning and chipping plant and the section for the technical inspection of materials; the forging and pressing section of the works includes two forging and one forging and pressing plant; the heat treatment section of the works (the heat treatment plant and the silver steel plant).

Only in the rolling plant have the OTK sections not yet been united.

The removal of the OTK organization from under the authority of the director of the works cannot be approved because the director – the chief representative of the State at the works – is responsible for the quantity and quality of production. An independent body of OTK personnel should be under his authority, supervised only by him and by the head of the metallurgical industry department of the Sovnarkhoz. At the same time the responsibility of plant heads for the output of high quality production should be increased thus assisting in "putting the house in order."

Thus, to improve the quality of production it is necessary:

a) to carry out a reduction of the OTK staff, the circumstances at the works and plant being duly taken into account;

b) to increase the responsibility of plant heads for the quality of production;

c) to decide on the transfer of the testing and control laboratories to the OTK or TsZL in conformity with the conditions which prevail at the works.

d) to revise all technological instructions, making use of the experience of recent years;

e) to provide works with general regulations as to what should be considered a breach in the technology of industrial processes and what should be the destination of the products in such cases;

f) to compile and improve one common instruction with regard to the accounting of current and useful defective material as well as the instructions regarding quarterly reports on production quality in each process, and separately according to the complaints received.

OUTSTANDING METALLURGISTS

P. M. OBUKHOV

V. B. Iakovlev

Pavel Matveevich Obukhov was born in 1820, into the family of a superintendent of the Votkinsk Works. His father, Matvei Fedorovich Obukhov came from a working-class family but attained the degree of mining engineer toward the end of his life. This was an exceptional achievement at that time. He is known as the designer of hydraulic motors and other industrial machinery. He succeeded in imparting his love of industrial life to his son Pavel.

In 1832, Pavel Obukhov entered the Petersburg Military Mining School (later renamed the Institute of Mining Engineers' Corps) and graduated in 1843, being awarded a gold medal. Obukhov's name was inscribed on the gold honors board in the conference room of the Institute.

After graduating from Mining School, P. M. Obukhov became assistant superintendent of the Goroblagodat Works in the Urals and two years later – superintendent of the Serebriansk Works.

At that time, in connection with the development of the machine building industry and other industries, military in particular, the necessity of improving the quality of metal arose. Some components required very large castings which could not yet be made. Initially, tools and other equipment were made of steel ("uklad" – natural steel) obtained from crude pig iron. Later on, bloomery steel replaced in turn by carburized (blister) steel from bloomery iron was used for this purpose. Afterwards, cast crucible steel was produced by melting several lumps of carburized steel in graphite crucibles. Carburized steel was also obtained from puddled iron.

The composition of bloomery and puddle iron was not uniform and hence carburized steel produced from this material was not uniform. When several pieces of this steel were melted in a crucible, the ingot was uniform but it was impossible to predict beforehand its composition. Therefore, the uniformity of an ingot, made from several crucibles, depended on the number of crucibles.

In 1846, P. M. Obukhov was sent to Germany, Belgium and France for two years to study the metallurgical industry in those countries.

At the end of 1848, P. M. Obukhov returned from his mission abroad and was appointed manager of the Kushvinsk Iron Works. In 1851, P. M. Obukhov, while manager of the Iugovsk Copper Works, studied the possibility of cast steel manufacture. In 1854, he was appointed manager of the Zlatoust Works where he met masters who had been assisting the great Russian metallurgist, P. A. Anosov, in the development of the process for the production of damask steel. Obukhov's investigations were thus greatly facilitated.

In 1854, P. M. Obukhov completed, in the main, the experiments on the production of crucible cast steel. This steel was initially used for cuirasses – bullet-proof breastplates. Previously, the cuirasses had been manufactured by the method of the French master Schprenger – by welding natural steel with iron; they were very heavy and up to 30% of them had to be rejected on testing. The introduction of Obukhov's steel resulted in the reduction of the weight of a cuirass by 40-50% and in the lowering of the amount of defective product. These cuirasses were much better than the ones made by Krupp. The gun barrel from the Zlatoust Works cracked at the 28th shot and the barrel from the Krupp works cracked as early as the 8th shot (equal charge being used).

Being convinced of the superiority of Obukhov's steel over the best foreign steels, the War Department ordered the production of weapons, cuirasses, gun barrels and tools from cast steel at the Zlatoust Works and later on at the Izhevsk and Sestroretsk Works.

In February, 1855, P. M. Obukhov proposed that cast steel should be employed in the production of cannons which, in his opinion, would be much lighter, cheaper and stronger than those made of copper. There was no response to this proposal. Only after the proposal was submitted again in 1857 did the War Department take notice of it. However, before Obukhov was entrusted with organizing the new production he was sent to Germany to study steelmaking processes at the Krupp Works, where he stayed from September, 1857, to February, 1858. His visit convinced Obukhov once again that he was right in submitting his project.

In June, 1858, the Tsarist government gave permission and provided means for the construction of a gun factory in Zlatoust according to Obukhov's design. By the beginning of 1860, the Kniaz Mikhailov Steel Works was put into operation. Initially, there were 96 two-crucible furnaces; by 1864, 113 two-crucible and 14 four-crucible furnaces were in operation. The capacity of each crucible being about one and a half pood (1 pood = = 36 U. S. lbs) ingots of about 300 pood weight could be cast as early as in the first year of operation. The first ingot, weighing 55 poods, was cast for a four-pounder which was bored and tested in Zlatoust. The gun withstood 3000 shots without cracking. At the same time three more ingots were cast, including one for a twelve-pounder of a light type. In the beginning of August 1860, all this material was sent to Petersburg and P. M. Obukhov went there too.

In the Petersburg Arsenal, a gun, similar to a Krupp gun, was machined from one of the castings and comparative tests were carried out. Obukhov's gun was charged with gun powder 20% more powerful than the powder charged into the Krupp gun. Obukhov's steel withstood 4000 shots without any cracking or deformation of the gun.

P. M. Obukhov's name became famous in Russia and abroad. In 1861 he was elected Corresponding Member of the Artillery Committee and appointed head of the Zlatoust Mining District.

The basis of cast steel production at the Kniaz Mikhailov Works was the crucible process. Preparation of steel from pig iron by crucible method was developed, theoretically and practically, by V. P. Anosov in the thirties of the 19th century. The method is described in the license issued to P. M. Obukhov in 1857. For the majority of steels manufactured by Obukhov's method, the charge consisted of white iron, iron and steel cuttings and magnetite. In the table below, the approximate composition of four types of charge is given (in pounds).

Components	For hard tool steel	For medium tool steel	For soft blade steel	For soft cuirass steel
White iron	12	8	6	4
Iron and steel cuttings	20	24	26	28
Magnetite	3	3	3	4
Arsenic	5/96	5/96	–	–
Loam	1/192	1/192	1/192	1/192

When smelted in a covered crucible, carbon from pig iron partially passes to iron and partially burns under the action of oxygen from the magnetite. Oxygen from the magnetite oxidizes silicon to silica which forms slag with some ferrous oxide and other impurities.

It can be seen from calculations of the charge for medium steel made by the great Russian Scientist D. I. Mendeleev that the proportions of the components of the charge were chosen very accurately by P. M. Obukhov. A thorough preparation of the charge and a large amount of iron ore in the charge made it possible for the steelmaking operations to be carried out simultaneously in several crucibles and to produce the required steel grade. Hence, the content of carbon and of other ingredients in steel was approximately the same in each crucible.

The high properties of the steel were due to the materials employed – free from harmful impurities but containing several beneficial elements. White iron, produced in a slightly modified refinery hearth from the pig iron of the Satkinsk Works, was obtained from very pure ores of the Bakalsk deposit , smelted with charcoal in a blast furnace. Magnetite from the Niziamska Mountain contained ilmenite ($FeO \cdot TiO_2$) and chromium. The effect of titanium, chromium and some other elements on the quality of steel was very beneficial.

Obukhov's success was so great that his plea for the expansion of the steel works in Zlatoust resulted in a decision by the government to build a new, large steel works in Petersburg. Technical supervision of the erection of the new works was entrusted to P. M. Obukhov who came to Petersburg in 1863.

On April 15, 1864, the first castings were obtained at the new works which was named the Obukhov Steel Works. The main foundry building was situated in the center of the works and consisted of a hall where castings were made, and two wings with 120 crucible furnaces, each furnace with a 2-pood capacity crucible. Many foremen, well skilled in the steel casting processes, were transferred to the works from Zlatoust.

Instead of steel and iron cuttings, steel from puddling furnaces was introduced into the charge. By 1870, there were 320 furnaces for crucible steel production and 8 puddling furnaces.

Great care was taken in the preparation of charge materials at the Obukhov Works. The sources of supplies remained the same. For a long time the pig iron for the crucible charge and for the processing in the puddling furnaces was obtained from the Satkinsk Works.

The supervision of the construction of two steel works put an enormous strain on P. M. Obukhov and greatly impaired his health. This outstanding metallurgist died on January 1, 1869.

Continuing the research works of P. P. Anosov, P. M. Obukhov succeeded in finding the solution to the problem of how to produce a large uniform ingot. Obukhov built the first steel works in Russia, which constituted the basis for the development of the steel casting industry. At these works a new generation of Russian metallurgists grew up – D. K. Chernov, A. S. Lavrov, N. V. Kalakutskii, A. A. Rzheshotarskii and others. Russian metallurgists succeeded in solving several important problems in cast steel production.

FROM THE HISTORY OF TECHNOLOGY

DEVELOPMENT OF THE ROLLING INDUSTRY

(UNTIL THE 20TH CENTURY)

L. M. Bekasova

It is difficult to determine when and where the first rolling mill was used. Various sources from the 17th century indicate that the rolling of nonferrous metal pieces between two rolls was widely known in European countries. This method was used for rolling not only plates but also shaped sections. The earliest description now known of a rolling mill for tin is given in Leonardo da Vinci's works and it refers to 1495.

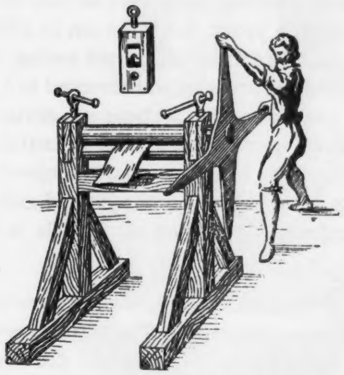


Fig. 1. Manually operated rolling mill.

Devices consisting of two rolls have been used since very early times for wheat ears processing, ore crushing and grain grinding (roll mills). With little modification they were applied to metallurgical processes. The most extensive use of the method of passing metal between rolls was made in the 17th century in the production of sheets for coin stamping where the product had to be of uniform thickness, and also in the production of sheets for organ pipes and for roofing. The mills for soft nonferrous metals were usually operated manually (Fig. 1).

In England, in the 17th century, lead plate 45 mm thick for production of lead sheets was passed 200 times between two rolls until it was rolled to 2.5 m thickness. Ten working hours were required for this operation. The mill was operated by six workers. After leaving the rolls, the rolled piece was placed on wooden rollers – the forerunners of modern table rollers. For iron processing, much more effort was needed and hence rolls had to be made much heavier and the mill mechanically driven. The mills were driven by a water wheel.

Iron was at first worked on so called "cutting" rolling mills where iron was rolled and cut into pieces of required width. The forging of thin rods required the expenditure of much labor and the rods produced were not uniformly thick. Therefore, metallurgists made use of the practice of copper wire manufacturers who cut copper plates with a saw driven by a water wheel.

A cutting mill consisted of several discs on a shaft, mounted in the gap between the discs of another shaft, and the two shafts contra-rotated. Thus, the cutting mill represented a combination of several disc shears. To obtain sheets of a uniform thickness, forged and heated iron plates were passed between smooth rolls (Fig. 2). This type of mill appeared in the middle of the 16th century.

In the beginning of the 18th century, rolling mills were used for the production of roofing iron. By then, their design was slightly improved. Larger mills had reversible driving gears with toothed wheels and a reversible coupling.

Screws and a loaded lever were employed for the adjustment of the gap between the rolls; the lever was especially convenient for smoothing and polishing of sheets. The method of roll production was considerably improved; instead of forged rolls, cast rolls made according to a clay pattern were used.

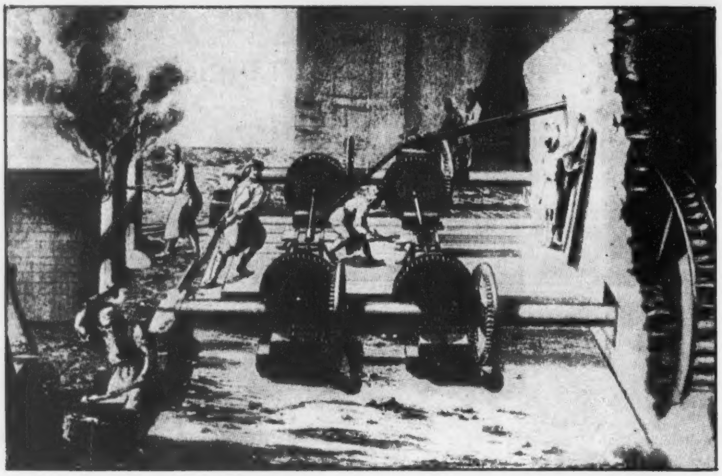


Fig. 2. Cutting mill. Stand with smooth rolls (left), cutting stand (center). Water wheel driving the mill is on the right.

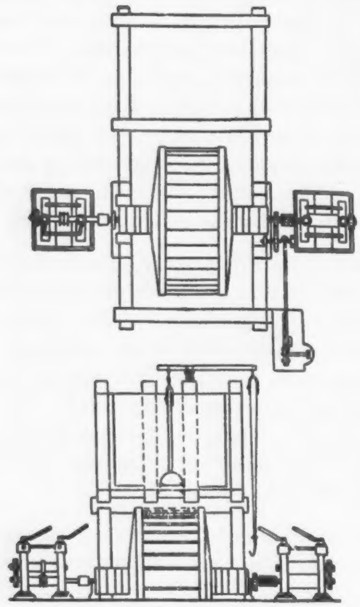


Fig. 3. Rolling and cutting mill of P. M. Zalesov design at the Tomsk Works.

Since the middle of the 18th century a multitude of designs of most various rolling mills were devised in European countries. In England, a patent was taken out in 1728 for a mill with shaped rolls for rolling corrugated roofing iron, a mill for rolling round rod and wire was invented in 1766, and a mill for rolling oval and square sections was devised in 1783. These mills, however, were not used on an industrial scale because before they could be commercially adopted their components had to be considerably strengthened and the speed of rolls increased, and this was not feasible at that time.

At the end of the 18th century, heating furnaces with one charging door were introduced. The furnaces were wood or coal fired, the heated metal being placed directly on the fuel layer.

With the appearance of the puddling process, rolling became one of the main operations in the iron industry.

In 1783, an Englishman, Henry Cort, suggested that blooms (which were reduced in size under the hammer and reheated) should be rolled on a rolling mill in order to finely shape them into sheets, rods, bars etc. This process was in essence very close to the modern rolling practice.

In the 18th century, the method of rolling was particularly extensively employed in England and Russia.

The first rolling mills in Russia for rolling of roofing iron were introduced at the Chermoz Works in 1782. Sheets were rolled from arshine plates (sheets of bloomery iron, 71 × 71 cm and not less than 0.5 mm thick). At that time, the mills began to be classified into roughing, section and plate mills. At approximately that time water-wheel-driven shears for cutting sheets were invented.

In 1792, a patent was taken out in England for a steam engine mill drive; the weight of rolls and the speed of rolling could be increased. Steam engines were adopted at new works, and water-wheel drive remained at the old works where the puddling process and rolling were employed. At the Tomsk Works, a water-wheel-driven

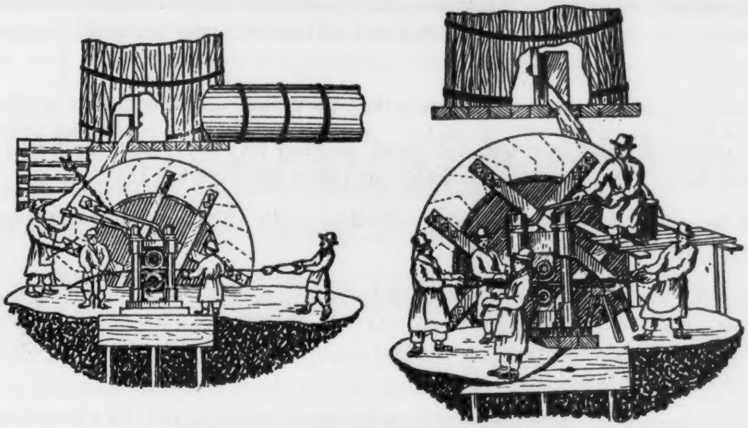


Fig. 4. Rolling mills at the Kirsinsk Works (1830).
On the left – roughing mill, on the right – finishing mill.

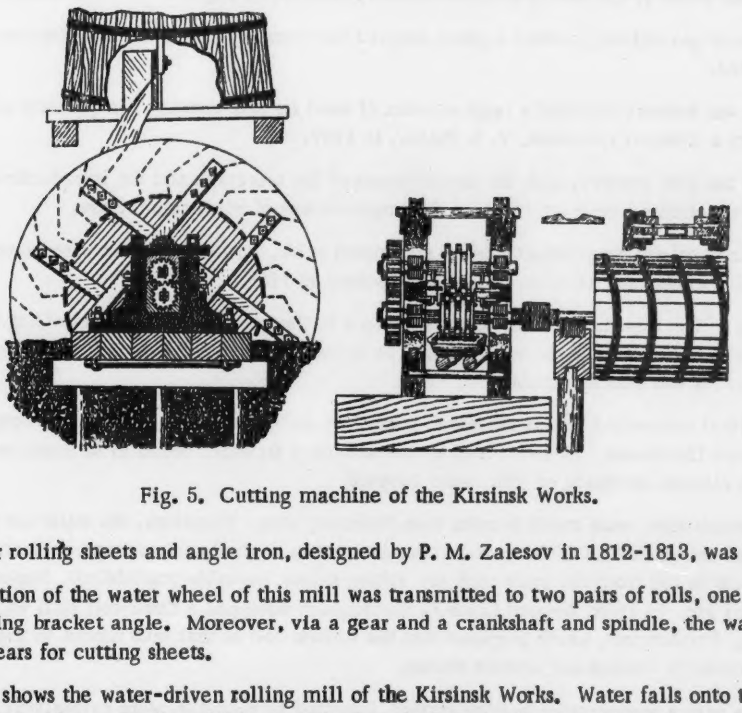


Fig. 5. Cutting machine of the Kirsinsk Works.

rolling mill for rolling sheets and angle iron, designed by P. M. Zalesov in 1812-1813, was installed (Fig. 3).

The rotation of the water wheel of this mill was transmitted to two pairs of rolls, one smooth and the other shaped for rolling bracket angle. Moreover, via a gear and a crankshaft and spindle, the water wheel actuated mechanical shears for cutting sheets.

Figure 4 shows the water-driven rolling mill of the Kirsinsk Works. Water falls onto the wheel through an opening provided with a gate; the mill is stopped when the gate is closed. Red hot bars are rolled in the roughing mill. The foreman adjusts the distance between rolls by means of screws, and checks the thickness of the plate which is then transferred to the finishing mill. Two workers support the plate with a bar, the roller feeds the plate between the rolls and an assistant pulls it with a pair of tongs.

After rolling, the plate was transferred to the cutting mill where it was cut into narrow strips.

On a steam driven mill (the Colle Works in Belgium), the rotation of the steam engine flywheel was transmitted to a toothed wheel mounted on a common shaft with the upper roll. Shears and a press were driven by the same flywheel. Blooms, reduced under the press, entered the roughing mill for preliminary rolling. The plate slabs produced were cut by the shears, heated in a furnace and transferred to the finishing stand of the mill.

Industrial development in the first half of the 19th century forced metallurgists to search for more efficient methods of metal production. The industry was not satisfied with slabs, bars, plates and rods. New sections were required.

After the invention of railroads, the rails constituted a large part of rolled production.

Beginning in 1826, rails were rolled from iron slab packs. Initially they were made 4.5 m long and later on were made up to 7.25 m long. Rails rolled from puddling steel were introduced in 1857.

Soon, circular saws for cutting hot rails appeared at rail rolling mills. The horizontal steam engine was introduced in the forties and fifties of the 19th century.

The growth of railroads made demands on metallurgists to develop methods for rolling wheels. In 1835, an Englishman, James Hardy, took out the patent for the manufacture of axles and wheels. The experience accumulated on the manufacture of wheels helped in the development of shaped rolled iron production. Up to 1830, only angle brackets and iron for sashes were rolled.

The design of furnaces for ingot and billet heating prior to rolling was improved. In 1843, Gustav Erickson modified the ordinary flame furnace by increasing the length of its hearth. The ingots in the furnace were moved from the charging door to the delivery door by means of a crowbar.

In 1848, K. Delen (Germany) invented a universal rolling mill for medium thickness plates of various sizes. By the fifties of the 19th century, the rolling of sheets directly from ingot began to be introduced.

The introduction of gas lighting created a great demand for tubes. By 1845, the manufacture of tubes by drawing had commenced.

The developing war industry required a large amount of steel for ship armor. The problem of rolling amor steel was first solved by a Zlatoust specialist, V. S. Piatov, in 1859.

By the sixties of the 19th century, with the development of the telegraph and the introduction of metal cables, metallurgists concentrated their attention on the improvement of wire manufacture.

The rolling industry gained great impetus when continuous mills, initially used for wire manufacture, were invented. The first mill, containing 16 rolls, was built by Bedson in 1886.

The introduction of the Bessemer process contributed to a further development of the rolling industry. Mills with cast steel rolls of large diameter were built. The speed of rolling and the draft could be increased. The length of rolled pieces was also increased.

Hard converter steel compelled mill designers to revise the design of mills. Mills were strengthened and some improvements were introduced. By 1875, mill drives without a flywheel began to be employed and frictional couplings which allowed reversing of rolls, were adopted.

Ingots from Bessemer steel were much heavier than bloomery iron. Therefore, the mills had to be mechanized. In the second half of the 19th century several inventors devised various improvements on the transportation of rolled ingots to and from the mills such as: lifting tables, movable scaffoldings, bogies, manipulators for turning rolled pieces etc. In 1862, Bernard Lauth in Birmingham equipped a three-roll mill with a lifting table and table rollers. Furthermore, Lauth proposed that the middle roll of that mill should be made idle so that a secondary pass could be carried out without tilting.

Holding furnaces with a regenerative heating system, invented by Siemens, were extensively used in the steel rolling industry.

In the sixties of the 19th century, cold rolling became more and more important in the USA, first for finishing operations and then for rolling agricultural implements.

In 1885, the Mannesmann brothers (England) invented the method of seamless tube manufacture, based on the principle of helical rolling between inclined rolls. In 1882, they constructed the pilger rolling mill for thick-walled tubes.

The first successful application of electric motors for mill drives took place in France and Germany in the nineties. In 1906, the first mill equipped with reversible drive from an electric motor was put into operation in Trschinz.

In 1908, automatic transfers for conveying rolled pieces from one stand to another in the same line or from the upper rolls of a three-high mill into the lower and vice versa, from the lower into the upper rolls, were invented. As a result, the output of light section and wire mills could be raised substantially.

At the end of the 19th century distinct specialized branches – section steel, sheet and plate, and tubular product – became established in the rolling industry. The demand for thin sheets could not be satisfied by the old inefficient mills with stands arranged in one line, and hence the idea of continuous mills for hot rolling of sheets emerged. In 1892, the first semi-continuous mill was built in Teplitz.

The cold rolling of sheets was introduced in the eighties of the 19th century.

As already mentioned, the first rolling mills in Russia were at works in the Urals. In 1843, the first production of rails in Russia for the Nikolaevska (now Oktiabrska) railroad which was being constructed at that time, was organized at the Vyksunsk Works. At the same time the production of rails at the Nizhne-Tagil' Works began. After the abolition of the serfdom, the development of the metallurgical industry in the South began. New works such as Sulinsk, Dnepropetrovsk, Briansk, Kramatorka, Nikopol and others rapidly appeared, and at the end of the 19th century the tube works in Ekaterinoslav, Nizhnedneprovsk, Taganrog, Mariupol and Lugansk were put into operation.

The development of the metallurgical industry and the growth of heavy industry increased the demand for rolled products. The main problems in the present development of the rolling industry are a higher speed of rolling, continuity and precision of rolling, as well as extensive mechanization and automation of the rolling processes.

METALLURGY ABROAD

THE STEEL ROLLING INDUSTRY IN ENGLAND*

A. V. Istomin

Section Steel Production

The largest continuous 280 mill for light section steel was built after the Second World War at the Park Gate Iron and Steel Works. The mill is designed for rolling of round, square and flat sections at a speed of 14 m/sec.

A new semi-continuous mill with a three-high roughing stand for rolling alloy steel is being built at the Samuel Fox Works.

There are several modern mills in England built before the war for wire rod, including mills with three or four rolling lines.

In connection with the development of the welded tube and plate industries which caused a heavy demand for flat rolled steel products, several new continuous mills for narrow plates and strips were built after the war. One of the sheet mills contains 12 stands with vertical and 8 stands with horizontal rolls. It produces strips with bevelled edges and plates up to 406 mm wide for cold rolling.

Plate and Sheet Production

Owing to the highly developed ship-building, boiler-building and bridge-building industries, great attention was always paid to the production of thick plate in England. Before the war, there were several large heavy-plate mills including six two-high reversible mills with two stands in one line driven from a common motor.

One of the biggest producers of steel plate was the plate rolling plant of the Appleby-Frodingham Works, built in 1927. It had one 3050 mm mill with two two-high reversible stands arranged in one line and one 3050 mill with a single two-high reversible stand. At one time, these mills were the most advanced in Europe with regard to mechanization; they were supplied by a slabbing and blooming mill designed for rolling 20-ton ingots.

In 1939, by the installation of a finishing four-high stand, the small mill was converted into a two-stand tandem mill. Behind the mill, a continuous roller-hearth furnace, about 60 m long, for normalizing and annealing plates was built. The larger mill at this works is also being modernized.

Mills of other works are also being modernized.

Side by side with the modernization, the building of new plate mills is planned. One of them, a 3800 mm mill with a four-high stand for the production of plate up to 3450 mm wide, is being erected at the Durham Steel and Iron Works. A new heavy-plate mill is planned at the Colvilles Works in Scotland.

The biggest reconstruction works, carried out in England after the war and involving large capital expenditure, were aimed at increasing the production of sheet by modern methods.

Before the war, thin sheets were produced mostly by rolling sheet billets in packs on two-high mills.

At the Richard Thomas and Baldwin Works there was one 1420 mm continuous hot-rolling sheet mill, its capacity being about 500,000 tons of metal per year, and two continuous mills for cold rolling; a 1420 mm three-stand mill for thin plate (mainly for cars) and a 1060 mm five-stand mill for sheet iron. At that time it was the only five-stand mill in Europe.

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*Continued from "Metallurgist" No. 3, 1958.

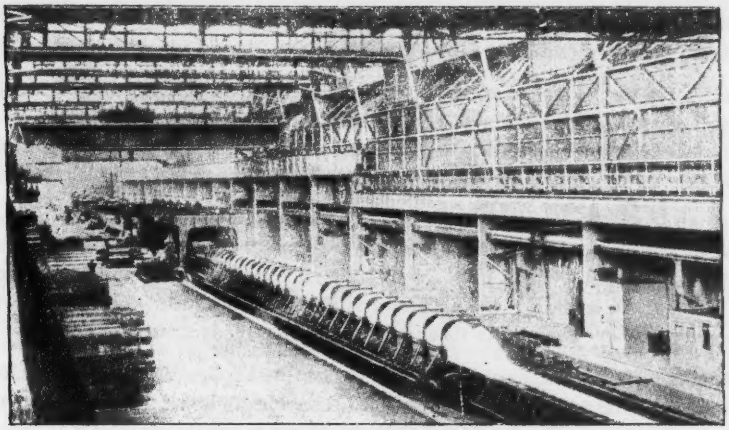

Fig. 1. 2030 mm continuous plate mill for hot rolling at the Abbey Works of the Steel Company of Wales (in the foreground are the sprayers for the cooling of plate).

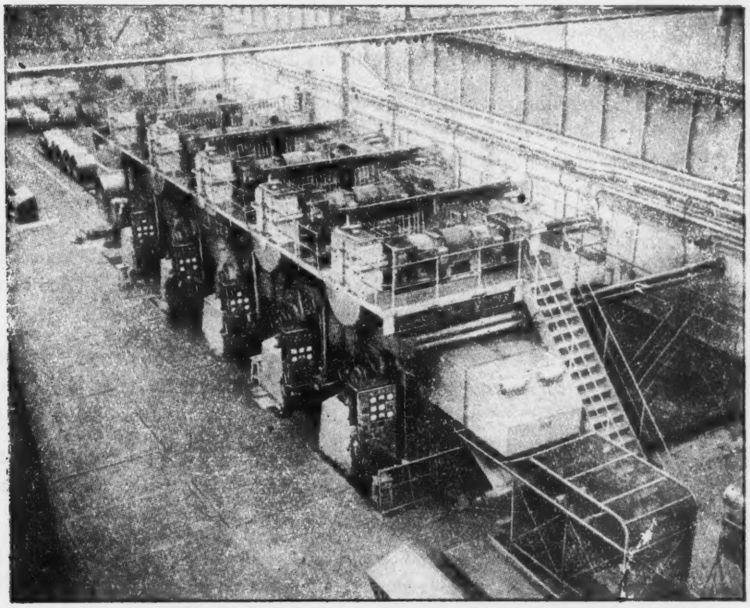

Fig. 2. New 1060 mm five-stand mill for cold rolling of steel sheet at the Richard Thomas and Baldwin Works.

In 1939 a second, 1520 mm continuous hot-rolling mill with 8 working stands (instead of the usual 10), whose output was planned to reach 1.5 million tons per year, was put into operation at the works of John Samuel and Sons. Later on, a 1400 mm continuous four-stand mill and a 2030 mm reversible mill for cold rolling were installed at this works.

After the war, the Steel Company of Wales began construction, in the Port Talbot district, of a new Abbey Works comprising an open-hearth plant, a slabbing and cogging mill and a 2030 mm continuous thin-sheet mill (Fig. 1) with a yearly output of 2.5 million tons.

In 1954, a new tin plate works, the Trostr Works, with a 1220 mm continuous five-stand mill for cold rolling with a capacity of 400,000 tons per year, was built and put into operation. The works employs modern

methods of tin plate manufacture including hot-dipped and electrolytic processes. The starting materials in the form of hot rolled coils are obtained from the Abbey Works.

Tin plate production has been reorganized at the works of Richard Thomas and Baldwin; the old five-stand mill for cold rolling has been replaced by a new, improved mill of the same size (Fig. 2). In addition, the Velindre tin plate works, similar in its equipment to the Trostr works, was build and partly put into operation in 1956. The Velindre Works has not yet its own pickling section and for the time being starting materials are supplied as hot rolled pickled coils by the Abbey Works.

Thus, at present, there are in England three continuous plate mills for hot rolling and six continuous mills for cold rolling including three five-stand mills for tin plate, a wide two-stand mill for the hot rolling of stainless steel plate up to 1000 mm wide, and two planetary mills for the hot rolling of 380 mm wide sheet. Work is in progress to increase the production of thin sheet by means of the modernization of existing plants.

It is planned to increase the output of cold rolled product by the erection of a new 1420 mm continuous four-stand mill and the modernization of existing mills at the Abbey Works and by a better utilization of the capacities of tin plate plants at the Trostr and the Velindre Works.

In connection with the substantial increase in the production of thin steel sheet by modern methods, old-two-high mills are being put out of operation. At the end of 1957, the Steel Company of Wales announced the discontinuation of the production of steel sheet on two-high mills. A similar announcement was made by Richard Thomas and Baldwin. Some of the remaining mills are used for rolling sheets from alloy steels (stainless, silicon, manganese and other steels).

The following observations can be made with regard to the production of steel sheet by modern methods:

1. All slabs for rolling on continuous plate mills go to storage and after cooling are inspected and dressed (up to 30%). The dressing of slabs increases the output of plates free from defects and make the operation of plate mills independent of the operation of the steelmaking plant and cogging mills. At our works, a considerable proportion of slabs is transferred from the slabbing mill directly to the plate mill.

2. Great attention is paid to the temperature of the metal during rolling, especially the temperature of the sheets during the coiling at the end of the rolling process. After delivery from the mill, the sheets are rapidly cooled with water so that they can be coiled at 650-680°C. This temperature ensures a good structure of metal, facilitates work on binding of coils and allows shorter conveyors for cooling.

3. In the new pickling machines of the cold rolling plants, the speed of the sheet in the baths reaches 150-180 m/min. Cascade pickling is employed. All machines are provided with efficient butt-welding equipment and burr removers, as well as with circular shears for trimming of sheet edges during pickling.

4. The fastest five-stand mill for cold rolling, built in England in 1956, has a maximum design speed of rolling of 25.4 m/sec. Palm oil is used in tin plate manufacture on this mill. On each stand there is a device for the recovery of palm oil.

5. The four-stand mill at the John Summers and Sons Works was made by adding a fourth stand to a three-stand mill. It is designed for rolling of sheet of minumum 0.35 mm thickness at 16.5 m/sec. The new four-stand mill at the Abbey Works will have approximately the same speed of rolling.

6. At all works, most of the cold rolled product is subjected to annealing and dressing in sheets: thin sheet coils are annealed in 8 ft. furnaces of 200 ton capacity, and coils for thin plate – in 4 ft. furnaces. All cupola furnaces are provided with floor ventilation. A speeded-up cooling of the charge under the cupola by blowing air from outside by means of special air blowers is applied. The first tower furnace for continuous annealing of thin sheets for tin plate is being built at the Velindre Works; its design output is 16 tons/hr.

7. Trimming of thin sheets for tin plate is carried out on a two-stand mill at a speed of 20 m/min.

8. Over 30% of the tin plate manufactured in England is made by an electrolytic process.

9. The grading of thin sheet and tin plate is mechanized. Accepted products are not subjected to an additional grading. The inspection of sheets on both sides is done only if required by the customer.

10. Tin plate is packed into large lots of 1000 kg or more weight. It is packed in paper or cardboard for home consumers, and in metal boxes for export. The packs are bound by means of special portable machines with bands or wire with a wooden plate fixed to the bottom of the packs for convenient handling during loading and transportation.

11. For transportation of material in cold rolling plant, trucks of 15 ton lifting capacity with a pick-up platform, are used as well as special tongs which can be attached to overhead cranes.

12. About 300,000 tons of galvanized sheet is produced annually in England. Material is hot-dip galvanized in sheets or strips by the Sendzimir method. There are also machines for electrolytic galvanizing.

13. Narrow strips of stainless steel are heated in continuous muffle furnaces in a protective atmosphere before hardening. Continuous furnaces are employed for the carburizing and annealing of transformer steel strips. There are several plants at the steel works in England for the production of curved shapes from strips and sheets. In one of them, shaped products are manufactured from hot-rolled strips up to 4.5 mm thick and 51-203 mm wide, from cold-rolled strip 1-3.2 mm thick and 9.5-533 mm wide. The plant produces about 3000 various shaped products. After bending, the material is cut into pieces of required length and then is subjected, as a rule, to several finishing operations: stamping of holes of different shapes, longitudinal bending, end grinding, painting, etc.

Thus, the steel rolling industry in England has been extensively modernized. At present, the increase in production is being achieved by increasing the range of rolled products, by the modernization of methods and by increasing the capacity of rolling plants.

OBITUARY

IVAN FEDOROVICH TEVOSIAN

On March 30, 1958, at 9:35 p. m., an outstanding statesman and Party member, one of the foremost organizers of the Soviet heavy industry, a Member of the Central Committee of the Communist Party of the Soviet Union, Deputy to the Supreme Soviet of the USSR, Plenipotentiary Extraordinary of the USSR in Japan, a Hero of Socialist Labor – Ivan Fedorovich Tevosian, passed away in Moscow after a prolonged and serious illness.

I. F. Tevosian was born in 1902 into the family of a tailor in the town of Shushe in the Azerbaidzhan SSR. In his youth he took an active part in the fight for the establishment of the Soviet regime in Azerbaidzhan. In 1918 I. F. Tevosian joined the Communist Party and in 1919 he held the post of Secretary to an underground Town District Committee of the Party in Baku, and on the victory of the Soviets he became secretary to the Party District Committee.

In 1921 I. F. Tevosian was elected delegate to the Xth Congress of the Communist Party and with a group of delegates took a district part in the liquidation of the Kronshtadt Mutiny. In the same year he was sent by the Party to study at the Moscow Mining Academy. Simultaneously with his studies he was carrying out Party work in the Zamoskvorets district.

After graduating from the Academy, I. F. Tevosian worked at the "Electrostal' " Works in the Moscow province as an assistant foreman, a foreman, the head of the steelmaking plants and the chief engineer of the Works. Here, his outstanding abilities as an engineer and metallurgist, and as an organizer and manager, revealed themselves.

I. F. Tevosian put a great deal of effort into the establishment of a new important branch of industry in our country – electro-metallurgy. In 1931-36 he held the post of the first Director of the Association of High-quality Steel and Ferroalloy Works "Spetstal'," of the people's Commissariat for Heavy Industry, and later he became the first Deputy People's Commissar of the Defense Industry of the USSR.

In 1939 I. F. Tevosian was appointed the People's Commissar of the Shipbuilding Industry and in 1940—the People's Commissar of the Ferrous Industry.

During the years of the Great Patriotic War, I. F. Tevosian devoted all his energy to increasing metal production for the war industry. At the time when the Ukraine was occupied, he worked hard for the establishment and development of the iron and steel industry in the East of our country. For his outstanding services to the country during the Great Patriotic War, I. F. Tevosian was awarded the title of a Hero of Socialist Labor.

In 1949 I. F. Tevosian was appointed Deputy Prime Minister of the USSR and took charge of the development of the ferrous and nonferrous industry and of the investigation of mineral resources of the country.

In December, 1956 I. F. Tevosian entered diplomatic services as the Plenipotentiary-Extraordinary of the USSR to Japan.

At the XVIth Congress of the Party, Comrade Tevosian was elected a member of the Central Control Committee. At the XVIIIth, XIXth and XXth he was elected a Member of the Central Committee of the Communist Party of the Soviet Union.

I. F. Tevosian was elected Deputy to the Supreme Soviet of the USSR of the 1st, 2nd, 3rd and 4th convocations. On March 16, 1958 the electors of the Oktemberiansk constituency unanimously voted him Deputy to the Supreme Soviet of the 5th convocation.

For his outstanding services, I. F. Tevosian was awarded five Lenin Orders, three Orders of the Red Banner of Labor and medals.

Death took from our ranks a selfless fighter for the happiness of the workers, himself an untiring worker, a talented organizer and a humble man. Soviet metallurgists will always treasure the memory of Ivan Fedorovich Tevosian – a faithful son of the Communist Party, whole-heartedly devoted to the great cause of communism.

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METALLURGIST IN ENGLISH TRANSLATION

April, 1958

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